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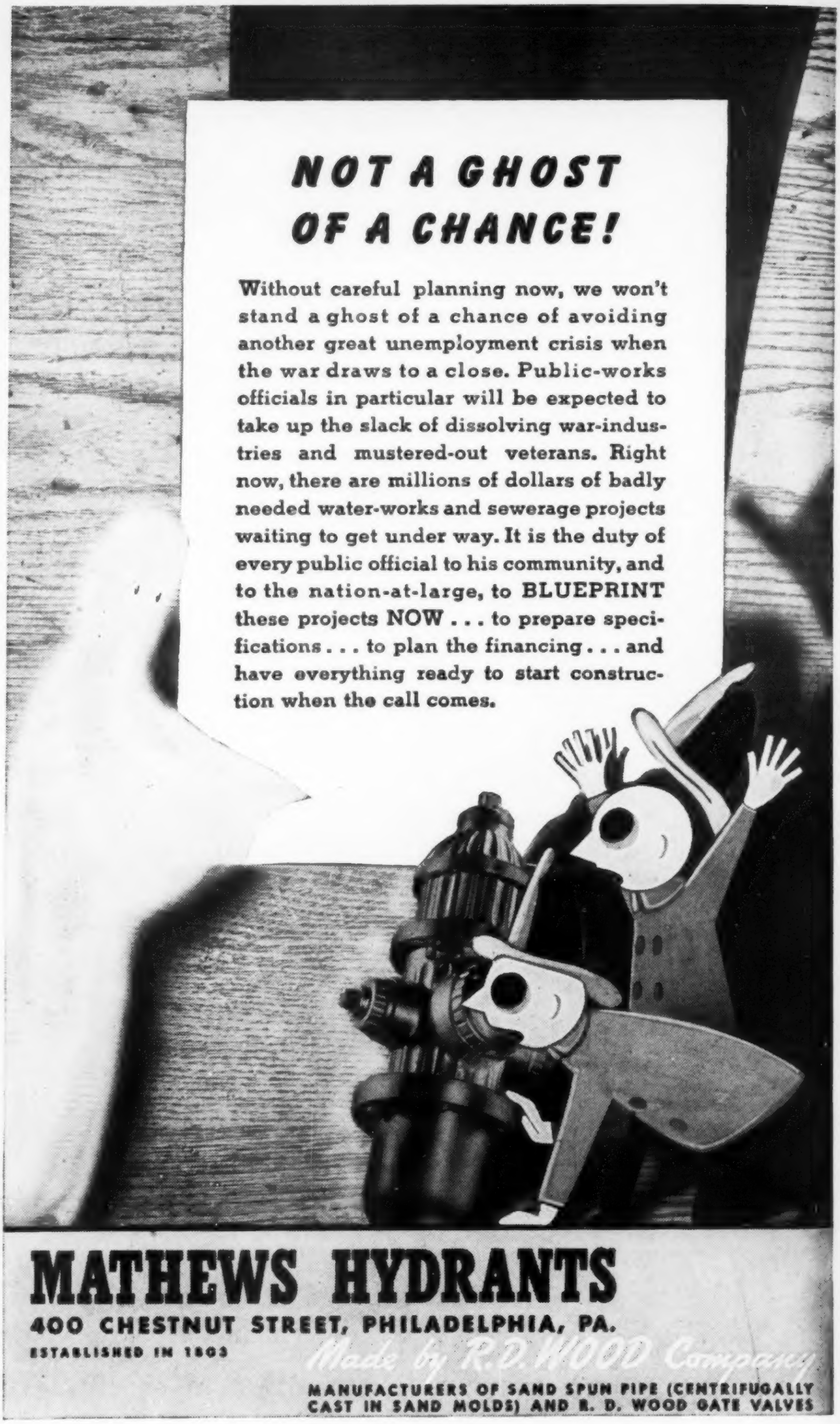

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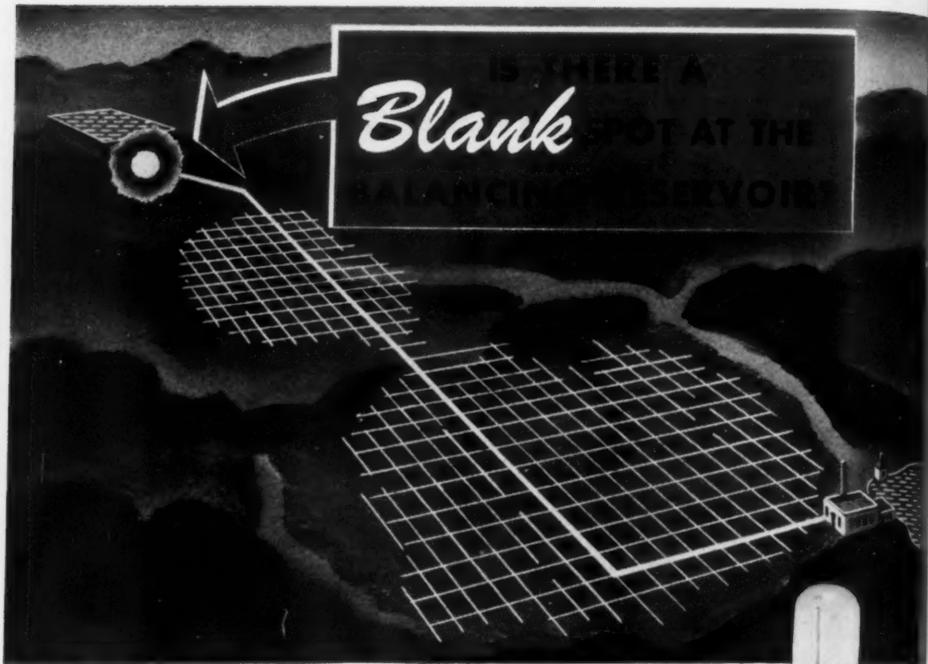

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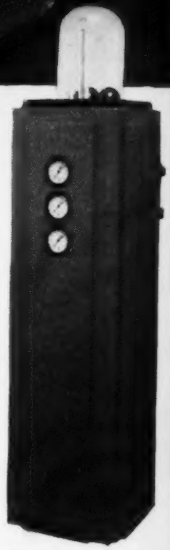

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The Design and Construction of the Milwaukee Water Works

By Joseph P. Schwada

MILWAUKEE was a city with a population of 100,000 when the original water works, with Lake Michigan as the source of supply, was placed in service on September 14, 1874. Prior to that time water for domestic purposes was obtained from wells and springs, and water for fire protection was taken from the three rivers flowing through the city. Several hotels conducted water from springs through mains made out of wooden logs. Not long ago some of these mains were removed and found to be in fairly good condition.

Since the original water works was completed in 1874, it has been expanded periodically to meet the increased demand for water resulting from annexation and growth in population, the expansion of industries, and the sale of water to suburban communities. On three occasions also the quality of the water delivered to consumers was improved: in 1910 by the use of chlorine; in 1925 indirectly by the building of the sewage disposal plant which reduced the pollution of the raw water; and in 1939 by the installation of the water purification plant, which was constructed after it was conclusively proved in the courts that further improvement in quality was both necessary and possible.

The original water works consisted of a pumping station with two pumps, each of 8-mil.gal. capacity; four boilers; a 36-in. diameter cast-iron pipe intake 2,100 ft. long; a standpipe; a reservoir of 21-mil.gal. capacity; and 50 mi. of mains from 6 to 36 in. in diameter. The pumping station was located on the shore of Lake Michigan, and the reservoir about a mile and a quarter west of the pumping station. The original station and the standpipe are shown in Fig. 1.[1]

A paper presented on June 13, 1944, at the Milwaukee Conference by Joseph P. Schwada, City Engr., Milwaukee, Wis.

[1] See pages 1044–1061 for figures and charts related to this article.

In the early years the pumps were operated intermittently depending on the level of the water in the reservoir. Even with a full reservoir poor pressures were experienced in some of the high sections of the city so a booster station was found necessary 4 yr. after the original plant was completed. This booster station was in operation for about 9 yr. when it was replaced by another. The second booster station was operated for about 37 yr. or until Riverside, the second major pumping station, was placed in service in 1924. The pumps in the second booster station had a total rated capacity of 25 mgd. and took their supply from a 30-in. suction line extended from the reservoir.

In less than 20 yr. the original 36-in. diameter intake became inadequate. During the period required for designing and constructing a second intake, a supplementary supply was obtained through an auxiliary intake consisting of 500 ft. of 30-in. diameter cast-iron pipe extending out into the lake. The original and auxiliary intakes were abandoned when the North Point intake was completed in 1895.

Anchor Ice

The depth of the water at the inlet of the original intake was 18 ft., and during its 20 yr. of service anchor ice occasionally caused considerable trouble. A wooden pier had been built over the intake at the time of its construction, and soon after the first experience with the ice a shelter house enclosing a boiler was erected over the inlet end of the intake. Whenever the ice formation at the inlet retarded the flow of water to the pumping station, the boiler was fired and steam forced against the ice, thereby clearing the inlet in from 20 to 60 min.

Original Pumping Engines

The two original pumping engines installed in the North Point Pumping Station were known as Striding Beam Compound Engines and derived their name from the large horizontal beam which was pivoted and supported on its center by an A-Frame (Fig. 2). The beam was caused to rock up and down by connections to the steam cylinders shown on the right. The opposite end of the "walking beam," as it was commonly called, was connected to the flywheel and to the water end of the pump. These engines were connected to a common flywheel and could be operated singly or in parallel. Each striding or walking beam was 33 ft. long, 6 ft. wide at the center, and composed of two $1\frac{3}{4}$-in. wrought-iron plates spaced 2 ft. apart. The plates could not be manufactured in this country and were made up, assembled and shipped from Manchester, England. The total weight of each beam was 15 tons.

These pumps had no governor, and fluctuations in steam or water pressure had a marked effect on the operation of the engines. They were manufactured by the Edw. P. Allis Co., Milwaukee, Wis., and developed a duty under test of 74,467,298 ft.-lb. of work per 100 lb. of coal. The pumps were removed in 1913 after 39 yr. of service and replaced by units of the vertical triple-expansion type.

In 1882 a third pump of 12-mgd. capacity was added to the North Point Station. It was known as the Steeple Compound Engine and was the only one of its kind ever built (Fig. 3). The steam end at the left was connected to the crankshaft and flywheel by means of a beam. The water end was directly below the steam end with

plungers of the differential type. The length of the piston rod which extended from the high-pressure cylinder down to the water plungers was 30 ft., and because of the length excessive vibration resulted.

The Steeple Compound Engine also had no governor and, as a result, its operation was irregular. This engine developed a duty of 104,820,431 ft.-lb. of work per 100 lb. of coal. After 38 yr. of service it was replaced by a vertical triple-expansion pumping engine having a capacity of 20 mgd. The Steeple Compound and the Striding Beam Compound Engines were operated jet condensing.

First Vertical Triple-Expansion Pumping Engine

It is of interest to point out that the first vertical triple-expansion pumping engine used for water works service in the world was built and installed in Milwaukee. In May 1886 the city advertised for a compound engine with a capacity of 6 mgd. for the second booster station. Prior to that time vertical triple-expansion engines had been installed on a few ocean-going steamers and were attracting considerable attention because of the increased economy over the compound engine.

The Edw. P. Allis Co. offered a three-cylinder compound engine with a guarantee of 100 million ft.-lb. of work per 100 lb. of anthracite coal, and as an alternate proposal a vertical triple-expansion pumping engine with a guarantee of 115 million ft.-lb. of work per 100 lb. of coal. The alternate proposal was accepted, and the unit was installed in 1887 (Fig. 4). On the official test a duty of 118,186,132 ft.-lb. was developed. The pumping engine had one high-pressure and two low-pressure cylinders set vertically. The crankshafts and flywheels were below the engines, and the water end was under the operating floor. This engine operated on 80-lb. saturated steam pressure. When the high-service booster station was shut down in 1924, this unit was still in good operating condition.

During the period from 1887 to 1927 several vertical triple-expansion pumping engines were installed in the major stations. Since then the city has installed two steam-driven centrifugal pumps. A complete summary of the pumps installed in all the stations since 1887, together with certain related data, are shown in Table 1.

Existing Water Works

The water works today includes two intakes, one of which is not in use but in serviceable condition; a water purification plant; two major pumping stations; and a distribution system divided into a low- and a high-service district with storage in each district (Fig. 5).

The water works today serves the city of Milwaukee, the city of West Allis and the village of West Milwaukee adjacent to the city on the southwest, and the villages of Shorewood, Whitefish Bay, and Fox Point located along the lake shore north of the city. The water works serves also several industries and county buildings in the adjoining townships and some individual consumers located just outside the city.

The total population served is about 667,800 of which about 602,000 are in the city. In 1940, which can be considered a normal year, the pumpage was 132 gpd. per capita. In 1943 the pumpage was 152 gpd. per capita, the increase being due primarily to industrial activity. The maximum daily

TABLE 1—*HISTORY OF PUMPING EQUIPMENT—MILWAUKEE WATER WORKS*

North Point Pumping Station

Designation No. of Pump		Type of Pump	Year Installed	Capac. —*mgd.*	Year Removed	Duty Developed—*ft.-lb. per 1000 lb. steam*	Steam Pressure Gage	Conditions Superheat	Steam per ihp-hr.	Builder
[Old No.]	1	Striding Beam Compound	1873	8	1913	74,467,298*	55	0	25	
	2		1873	8	1913		55	0	25	Edw. P. Allis & Co.
	3	Steeple Compound	1882	12	1919	104,820,431*	55	0	15.0	
[New No.]	4 L	Vertical Triple	1891	18	In service	154,048,704	125	0	11.68	
	5 L		1906	20	In service	162,338,670	125	0	11.36	Wisconsin Engine Co.
	6 L		1908	20	In service	167,277,220	125	0	11.51	
	7 H		1909	12	In service	175,400,000	125	0	11.11	
	8 H		1911	12	In service	171,353,000	125	0	11.25	
	1 H		1914	12	In service	183,108,000	125	57°	10.50	Allis-Chalmers Mfg. Co.
	2 H		1915	12	In service	184,994,000	125	64°	10.39	
	3 L		1920	20	In service	179,185,842	125	62°	10.50	

H = high service; L = low service * duty per 100 lb. of coal

High-Service Station (Removed—18th & Chestnut Sts.)

Designation No. of Pump	Type of Pump	Year Installed	Capac. —*mgd.*	Year Removed	Duty Developed	Steam Pressure Gage	Conditions Superheat	Steam per ihp-hr.	Builder
1	Horizontal	1878	0.75	1887	50,074,896*				Cope & Maxwell Mfg. Co.
2†	St. Paul Vertical	1884	3.0	1887	No record				Edw. P. Allis & Co.

* duty per 100 lb. of coal † No. 2 pump moved to 10th & North Ave.

High-Service Station (Removed—10th & North Ave.)

Designation No. of Pump	Type of Pump	Year Installed	Capac. —*mgd.*	Year Removed	Duty Developed	Steam Pressure Gage	Conditions Superheat	Steam per ihp-hr.	Builder
1	St. Paul Vertical Compound	1888	3	1924	No record	80	0		
2	Vertical Triple	1887	6	1924	118,186,312*	80	0		Edw. P. Allis & Co.
3		1892	8	1924	122,237,055*	80	0		
4		1904	8	1924	139,200,941	80	0		Allis-Chalmers Mfg. Co.

3	Vertical Triple	1892	8	1924	122,237,055*	80	0		Allis-Chalmers Mfg. Co.
4	Vertical Triple	1904	8	1924	139,200,941	80	0		Allis-Chalmers Mfg. Co.

TABLE 1—(*Continued*)

Riverside Pumping Station

Designation No. of Pump	Type of Pump	Year Installed	Capac. —*mgd.*	Year Removed	Duty Developed— *ft.-lb. per 1000 lb. steam*	Steam Pressure Gage	Conditions Superheat	Steam per ihp-hr.	Builder
1 H	Vertical Triple	1924	22	In service	214,545,000	199	129.2°	9.05	Allis-Chalmers Mfg. Co.
2 H	Vertical Triple	1924	22	In service	213,266,000	200.5	118.8°	8.97	Allis-Chalmers Mfg. Co.
3 H	Vertical Triple	1924	25‡	In service	205,860,000	200	119.5°	9.13	Allis-Chalmers Mfg. Co.
4 L	Vertical Triple	1927	25	In service	200,963,000	199	118.0°	8.92	Allis-Chalmers Mfg. Co.
5 H	Turbo-Centrifugal	1928	40*	In service	176,002,000	195.8	108.63°	10.99	DeLaval Steam Turbine Co.
6 H	Turbo-Centrifugal	1932	60†	In service	197,916,000	206.68	109.68°	9.79	Allis-Chalmers Mfg. Co

H = high service; L = low service * 280-ft. Head † 300-ft. Head ‡ This was later changed to a 15 mgd. high.

Booster Station

Pump No.	Type of Pump	Year Installed	Rated Capac. —*mgd.*	Rated Head—*ft.*	Guaranteed Efficiency—%	Acceptance Test			Builder
						Capac. —*mgd.*	Head —*ft.*	Efficiency —%	
1	Motor Centrifugal	1934	30	250	83	33.30	256.08	87.9	Allis-Chalmers Mfg. Co.
4	Motor Centrifugal	1938	30	250	83	31.86	266.19	89.46	Allis-Chalmers Mfg. Co.
2	Motor Centrifugal	1939	30	250	83	31.66	259.00	83.01	Pump—DeLaval Steam Turb. Co. Motor—Electric Mach. Co.

All 3 are rated 1500 hp., 900 rpm., 2300 v., 3-phase, 60 cycle

Purification Plant

Pump No.	Type of Pump	Year Installed	Rated Capac. —*mgd.*	Rated Head—*ft.*	Guaranteed Efficiency—%	Capac. —*mgd.*	Head —*ft.*	Efficiency —%	Builder
1	Motor Centrifugal	1938	20	80	83	17.40	91.636	85.80	Allis-Chalmers Mfg. Co.
2	Motor Centrifugal	1938	20	80	83	19.10	87.158	87.20	Allis-Chalmers Mfg. Co.
3	Motor Centrifugal	1938	50	30	83	53.3	30.998	88.50	Allis-Chalmers Mfg. Co.
4	Motor Centrifugal	1938	50	30	83	51.2	30.684	88.20	Allis-Chalmers Mfg. Co.
5	Motor Centrifugal	1938	50	30	83	51.6	30.798	88.30	Allis-Chalmers Mfg. Co.
6	Motor Centrifugal	1938	50	30	83	51.2	30.580	87.70	Allis-Chalmers Mfg. Co.
7	Motor Centrifugal	1938	75	30	83	85.1	31.067	86.70	Allis-Chalmers Mfg. Co.

Pumps 1 and 2 are wash-water pumps. Rated 350 hp., 720 rpm., 2300 v., 3-phase, 60 cycle
Pumps 3, 4, 5, and 6 are raw water pumps. Rated 350 hp., 300 rpm., 2300 v., 3-phase, 60 cycle
Pump 7 is a raw water pump. Rated 500 hp., 240 rpm., 2300 v., 3-phase, 60 cycle

pumpage and consumption was 160 mil.gal. and occurred in 1936. The maximum hourly rate of consumption was 302 mgd. and also occurred in 1936. The maximum yearly average daily pumpage and consumption occurred in 1943 and was 101,402,000 gal. A comparison of this amount with the yearly average daily pumped in 1875, i.e., 2½ mil.gal., explains why, over the years, larger intakes had to be constructed, pumping station capacities increased, and the distribution facilities expanded.

Intakes

The North Point intake, which is presently not in use, was completed in 1895 and can be used to supply water to the pumping stations where it would be chlorinated prior to distribution. It consists of a brick-lined tunnel 7½ ft. in diameter and 3,146 ft. long, extending from the lake shore shaft to an exposed crib. From the crib two cast-iron pipes, each 5 ft. in diameter, extend 5,000 ft. into the lake and terminate in 60 ft. of water.

The Linnwood Avenue intake now in use was placed in service in 1918 and consists of a 12-ft. diameter concrete tunnel 6,565 ft. long with its inlet in 67 ft. of water. The tunnel is 83 ft. below the bottom of the lake at the inlet end and is connected with a submerged crib by means of a 12-ft. diameter shaft carried slightly above the bottom of the lake. The intake crib is octagonal in shape, 80 ft. in diameter and 12 ft. high. The lake surface is approximately 55 ft. above the top of the crib. No trouble has been experienced with ice at this intake.

The intake tunnel terminates at the shore end in a shaft 15 ft. in diameter. From this shore shaft a 12-ft. diameter raw water tunnel extends easterly to the water purification plant. Another 12-ft. diameter filtered water tunnel extends westerly from the plant to a second shore shaft located adjacent to the one at the terminus of the intake tunnel. The latter shore shaft and the two 12-ft. tunnels on the site of the water purification plant were constructed as part of that project.

Before the water purification plant was constructed, one 9-ft. diameter tunnel, 5,700 ft. long, conducted the raw water from the original shore shaft to the North Point Station and another 9-ft. diameter tunnel, 7,100 ft. long, conducted the raw water to the Riverside Pumping Station. Today both of the 9-ft. tunnels are connected to the second shore shaft and conduct the filtered water to the stations.

A bypass consisting of a dry well and two gates was constructed between the two shafts. In the event of a serious interruption of power on both incoming lines to the plant, the gates can be opened and an unfiltered but chlorinated supply furnished.

The Linnwood Avenue intake has a capacity of 220 mil.gal. in 24 hr. at a velocity of 3 fps. and a capacity of 360 mil.gal. at a velocity of 5 fps.

North Point Pumping Station

The original station, North Point, has been remodeled several times since 1874. At the present time the pumping equipment consists of 8 vertical triple-expansion pumping units with a total rated capacity of 126 mil.gal. in 24 hr. Four of the pumps supply the low-service district with a discharge pressure of 65 psi. and four supply the high-service district with a pressure of 120 psi. The boiler equipment consists of two 300-hp. and three 400-hp. horizontal water tube boilers. The

steam pressure is 140-lb. gage with 100°F. superheat. The discharge mains from this station are 30 to 42 in. in diameter and are cross-connected. The 4-ft. diameter standpipe enclosed in an ornamental water tower originally served to reduce the pulsations produced by the two original pumps, and at the present time permits accumulated air to escape from the pumping station discharge mains. The layout of suction tunnels and discharge piping and the arrangement of pumps and boilers is shown in Fig. 6.

Riverside Pumping Station

The Riverside Pumping Station, in service since 1924, is located on the west bank of the Milwaukee River about 1½ mi. from Lake Michigan. The installed pumping equipment consists of four vertical triple-expansion pumping units with a total rated capacity of 84 mgd. and two turbo-centrifugal pumps, one with a capacity of 40 mgd. and the other with a capacity of 60 mgd. One of the vertical triple-expansion pumps supplies the low-service area and the other pumps supply the high-service area. Each pump discharges into a 42-in. diameter cast-iron main, and the six 42-in. mains merge into three 54-in. diameter cast-iron mains before entering the gate house. Bypass connections are provided in the gate house. The boiler equipment consists of six 400-hp. horizontal water tube boilers. The steam pressure is 200-lb. gage with 100°F. superheat. Most of the high-service water is pumped at this station. The layout of the 9-ft. tunnel from the lake, the suction tunnel in the pumping building, the discharge piping, and the arrangement of the pumps and boilers are shown in Fig. 7.

When this station was planned in 1921, studies were made and it was decided that, from the standpoint of reliability of service, steam-driven equipment should be used. At that time a continuous supply of electric power could not be assured. A comparison was also made at that time of the economy of vertical triple-expansion pumping engines and of turbo-centrifugal pumps, and the results indicated that the former type of pumping equipment should be used. In 1927 a fourth unit of that type was installed.

In 1928, when it became advisable again to increase the pumping capacity of the station because of the very rapid increase in demand for water, the two types of equipment were reconsidered and a turbo-centrifugal pump was selected. It was appreciated that, while the vertical triple-expansion units operated very efficiently, the over-head involved was extremely high because of the initial cost. In contrast, the lower cost of the turbo-centrifugal pumps, about one-third of the cost of the other type, together with the increased efficiencies then being rapidly developed, showed that the city was justified in selecting the centrifugal pump.

It is interesting to note the development that had taken place in both types of pumps between the years 1921 and 1927. In 1921 the city received a guarantee of 200 million ft.-lb. per 1,000 lb. of steam for a 22-mgd. vertical triple unit operating against a 280-ft. head, and in 1927 a guarantee of 208 million ft.-lb. per 1,000 lb. of steam for a 30-mgd. vertical triple unit operating against the same head. This is an increase in duty of 8 million ft.-lb., or 4 per cent, over a period of 6 yr.

For a 30-mgd. centrifugal pump the city received a guarantee of 158 million ft.-lb. per 1,000 lb. of steam in 1921 and a guarantee of 179 million ft.-lb.

per 1,000 lb. of steam in 1927. This is an increase of 21 million ft.-lb., or 13.3 per cent, in the duty, over the same 6-yr. period.

In 1932 the city installed a second turbo-centrifugal pump with a capacity of 60 mgd. to operate against a head of 300 ft. The duty developed in the official test was 197,916,000 ft.-lb. per 1,000 lb. of steam.

The records thus show a most interesting fact, and that is that in the city of Milwaukee there was built and installed the first vertical triple-expansion pumping engine ever used in a water works and also that here was built and installed the last unit of its kind.

Distribution System

Topographic conditions have necessitated the division of the city into a low-pressure district of about 14 sq. mi. and a high-pressure district of about 30 sq.mi. (Fig. 5). The highest elevation in the low-service area is 80 ft. above city datum and in the high-service area 215 ft. above city datum. Lake level varies from about 2 ft. above to 3 ft. below city datum.

Today the distribution system consists of 1,007 mi. of water mains including 16 mi. of hydrant pipe. Mains vary in size from 4 to 54 in. in diameter. The total length of 4-in. mains in the city is approximately 7 mi. and practically all were acquired through annexation. It has been the policy of the department during the past 10 to 15 yr. to install 8-in. mains as a minimum size in preference to 6-in. mains because of fire requirements and the increased peak rate of use. All pipe is cast iron, Class C, pit cast, in 12-ft. lengths.

In the residential areas 6-in. and 8-in. diameter service mains are generally used in both directions with alternate 12-in. and 16-in. diameter mains in the more important streets approximately $\frac{1}{2}$ mi. apart. The latter are supplied from the large feeder mains, 20 to 54 in. in diameter, extending from the pumping stations and reservoir. Most service mains are cross-connected at street intersections.

Gate valves in the 6-in. and 8-in. diameter mains are spaced at about 300 ft. so that no more than two blocks of main need be out of service for repairs. Valves in the 12-in. and 16-in. diameter mains are spaced at about 400 ft. and 500 ft. respectively. Gate valves are also installed in 6-in. and 8-in. diameter mains at their points of connection to the 12-in. and 16-in. diameter mains. In the 20-in. to 54-in. diameter mains the valves are located not farther than $\frac{1}{2}$ mi. apart. These larger valves are equipped with a by-pass and operated through gearing and are set horizontally in a special manhole. All valves are manually operated with the exception of one 48-in. and one 54-in. electrically-operated valve near Riverside Pumping Station. The total number of gate valves in the system is 19,300.

The total number of hydrants now in use is 8,621. There are three different types, each equipped with a $5\frac{1}{4}$-in. diameter main valve with single or double compound hose and steamer nozzle. Some of the earlier hydrants have frost jackets.

In residential areas hydrants are located at each street intersection with an intermediate one in the center of blocks more than 500 ft. long. In the industrial districts the hydrants are set with a maximum spacing of 300 ft. In the congested value districts where the double main system predominates three or more hydrants are set at the

street intersections with intermediate ones located within the block, the number depending on the length of the block.

Prior to 1928 all mains were laid with lead and jute joints. The tendency of such joints to leak after years of service led the department to turn to other jointing materials and since 1931 all joints have been made with dry braided hemp and a jointing compound. The jointing compound was first used in 1928 in a 30-in. diameter main laid under 25 parallel railroad tracks. A 16-in. main with lead joints had previously been laid at this same location, and frequent repairs were required to stop the joint leakage caused by the vibration of passing trains. Repairs are still being made periodically to the lead joints in the 16-in. main, but up to the present time the compound joints in the 30-in. main have required no maintenance. Of the total 1,007 mi. of mains in the distribution system approximately 100 mi., ranging in diameter from 6 to 54 in., are laid with a jointing compound. These joints require occasional repairs but to a considerably less degree than do the lead joints.

Storage in Distribution System

The original uncovered reservoir built in 1874 still serves the low-service distribution system, but in 1929 its capacity was increased to 25 mil.gal. by guniting the inside and raising the overflow (see Fig. 8). Its sides are rolled embankments lined with stone blocks. The slopes are one and one-half to one on the inside, and one and three-quarters to one on the outside. The dimensions of the irregular shaped reservoir are roughly 490 × 350 ft. with a depth of 25 ft.

The embankments were built in layers 9 in. thick, each layer being rolled with a heavy iron roller. The material excavated on the site was used for forming the embankments, and an additional 40,000 cu.yd. of earth was hauled to the site. The reservoir rests partly upon cut and partly upon filled ground.

The original interior surface was covered with a clay puddle 2 ft. thick and a 9-in. layer of broken stone upon which was placed a sandstone paving 15 in. thick laid in natural cement mortar. The bottom of the reservoir has an additional layer of concrete 4 to 6 in. in thickness. In 1929 the entire interior was given a 2-in. coating of "Gunite." This coating reduced the leakage from the reservoir by about 97 per cent—from 1 mil.gal. per 24 hr. to approximately 30,000 gal. per 24 hr.

The reservoir floats on the line, discharging water during the heavy consumption hours and filling during the off-peak hours. This permits a more uniform operation of the low-service pumps and frequently makes unnecessary the starting of another pump. Dropping the level of the water in the reservoir 1 ft. per hour is the equivalent of pumping into the distribution system at a rate of 24 mil.gal. per 24 hr.

The high-service distribution system includes two $1\frac{1}{2}$-mil.gal. elevated steel storage tanks and a booster station consisting of two 6-mil.gal. ground-level all-welded-steel storage tanks and a pump building housing three 30-mgd. motor-driven centrifugal pumps (Fig. 9). Provision is made for the addition of another 30-mgd. unit so that ultimately the total rated pumping capacity at this station will be 120 mgd. for the number of hours limited by the amount of water which can be stored at this location.

The storage facilities in the high-

service system are operated during the summer months only, the tanks being filled in May and drained in October. All tanks are filled at night under system pressures. The Jackson Park elevated tank is automatically taken off the line when filled and kept in reserve until it is again thrown on the line by a time switch at about 5:00 P.M. when the sprinkling peak comes on. The Hawley Road elevated tank floats on the line continuously discharging into the system or filling as the consumption demands dictate. The Menomonee Valley Booster Station is manually controlled and operates during the peak period on high consumption days, 5:00 P.M. to about 7:30 P.M.

A layout of the booster station showing the arrangement of the building, tanks and mains is shown in Fig. 10.

Foundations of Storage Tanks

When plans were being prepared for the first 6-mil.gal. steel storage tank, borings were taken to determine the nature of the underlying soil. Loading tests were also made to determine the reasonable bearing power of the soil and the settlement under various loads. As a result of the investigation, it was decided that the soil would safely support the load superimposed upon it by the tank filled with water amounting to about 3,500 lb. per sq.ft. under the piers and 2,500 lb. per sq.ft. under the slab. The foundation or support for the tank is shown in Fig. 11. This consists of a 12-in. circular reinforced concrete slab under the entire area of the tank with a concrete wall footing around the perimeter of the slab. The center steel column and the intermediate steel columns of the tank are supported by concrete footings extending below the 12-in. slab. A ½-in. layer of sand mixed with tar was laid on top of the concrete slab to act as a sort of cushion for the steel tank.

After the tank was in service for a few months, difficulty was encountered with the foundations. Levels taken periodically showed that the concrete slab was settling unequally. It therefore became necessary to shim up the interior steel columns so that the bottom of the exterior wall and the bottom of the columns would be in a plane even though the plane was not horizontal. It also became necessary to repair several cracks which had developed in the bottom plate due to the settlement. This procedure was repeated a number of times until the tank reached its final settlement of about 4 in. on one side and about 6 in. on the opposite side.

When plans for the second tank were prepared, the conditions were again studied. It was appreciated that the type of foundation used in the first tank should not again be used. After considering all the information available, it was decided to use piling under the wall of the tank and under the center cluster of interior columns. It was also decided that the bottom steel plate should be sloped downward from the interior columns and then upward toward the exterior wall. The arrangement adopted is shown in Fig. 11.

When this plan was adopted, it was expected that the bottom plate would settle and that cracks in it might occur. It was believed, however, that the settlement would not be serious and that the cost of repairing a few cracks would be much cheaper than the cost of piling and concrete beams under the entire bottom. The tank was placed in service, and the bottom plate did settle a maximum amount as shown, but up to the present time no cracks have developed. The lesson learned

from the first tank proved of value in the design and construction of the second tank.

Water Purification Plant

The water purification plant was placed in operation in 1939. It is located on the shore of Lake Michigan near the north end of the city and occupies a part of the beach and filled ground enclosed and protected by a steel revetment wall. The buildings are of Gothic design surrounded by attractively landscaped grounds which do much to enhance the appearance of the lake shore. All buildings are of Lannon stone. The total area of the site is 26 acres.

The plant consists of four inter-connected buildings and several underground structures as shown in the general plan (Fig. 12). The chemical building is flanked by the pump building (north), the service building (south), and, to the east, the filter building. The surge relief chamber, coagulation basins, filtered water reservoirs and wash-water tank are all underground.

The surge relief chamber was constructed directly over the raw water tunnel. The so-called wash-water "tank" is in reality a concrete underground reservoir located on top of the bluff in the park a short distance west of the plant.

The plant is of the mechanical rapid-sand type and has a rated filtration capacity of 200 mgd. This capacity is based on the conservative rate of 2 gpm. per sq.ft. of sand area, or a rate of $6\frac{1}{4}$ mgd. per filter for 32 filters. It is believed that the plant can be operated at the rate of 300 mgd. and still provide water of satisfactory quality.

The two underground reservoirs and the clear well under the filters have a total capacity of 30 mil.gal. The wash-water tank has a capacity of 750,000 gal.

Provisions have been made for doubling the capacity of the plant without interrupting operation of the present plant or making any material changes within it except replacing some of the low-lift pumps with larger units.

There are five motor-driven centrifugal pumps, four having a capacity of 50 mgd. and one having a capacity of 75 mgd., which pump the raw water against a head of 30 ft. into the coagulation basins. Two pumps, each having a capacity of 20 mgd., pump filtered water from the effluent channel against a head of 80 ft. into the wash-water reservoir through a 60-in. steel conduit. The pump room is shown in Fig. 13.

There is a city-owned transformer station in the rear of the pump building and power is supplied by the Wisconsin Electric Power Co. through two separate power lines.

The discharge from the centrifugal pumps passes horizontally through check valves into a steel pipe encased in concrete and encircling the outside of the pump room about 10 ft. under ground level. Two 84-in. steel conduits conduct the water from the discharge end of the loop through the sub-basement of the chemical house to the coagulation basins, one connecting to the north and the other to the south coagulation basin. These loops are cross-connected so that either side of the loop can deliver to either coagulation basin. Motor-operated butterfly valves are located at various points in the loop for that purpose.

Provisions have been made for the application of chemicals (lime, alum, activated carbon and chlorine) to the raw water pipeline between the pumps

and the mixing basin. Provisions have also been made for the application of carbon at the outlet of the settling basin and for ammonium sulfate and chlorine to the effluent tunnels between the clear well and the gate house. The interior of the chemical dry feeder room is shown in Fig. 14.

The coagulation basins are of the double-deck type with the mixing and flocculating chamber at the inlet ends and the sedimentation basin at the other end. Each coagulation basin is divided by a solid partition wall extending the full length so that actually there are four basins.

Two rows of mechanically-driven paddle wheels, rotating about a horizontal shaft, and two wooden baffles extending down from the ceiling of the mixing chamber to within 3 ft. of its floor provide the necessary mixing and floc building (Fig. 15).

The filter building is directly over a filtered-water clear well or reservoir. There are 32 filters constructed in four rows of eight each along either side of two parallel operating aisles (Fig. 16) and pipe galleries.

A transverse or center gallery and a main aisle divide the rows so that the filters are arranged in groups of four. The width of each operating aisle is identical with the width of the pipe gallery below. The top slab of the settled water conduit, extended across the gallery, forms the operating floor between the filters. The ceiling of the center gallery forms the floor of the main aisle above.

The surface wash system consists of a line, with a hydraulically-operated valve, extending from the wash-water header in the pipe gallery into the filter, a U-shaped header around the inside of the filter box and laterals laid across the filter. The control for the system is located at the operating table.

Each filter is equipped with a rate controller, set with the center line of flow vertically down, provided with a fluid counter weight so that it can be filled or emptied. Rate of flow is adjusted at the operating table by buttons which in turn control the quantity of fluid in the counter weight.

A combined rate-of-flow and loss-of-head gage is attached to each rate controller. The gage, which indicates and records on a 30-day strip chart, is actuated through linkage of pots placed in the operating table. Pressures are transmitted to the pots through the use of air pressure and piezometer tubes.

The 36-in. wash-water headers in the pipe galleries, in addition to being connected to the 60-in. wash-water header in the south gallery, are cross-connected in the north gallery by a 60-in. steel pipe. This size is used there so that, when the plant is expanded, another 60-in. wash-water header from a second wash tank will fit in readily with the present layout in the north gallery. The 60-in. lines in the north and south galleries and the 30-in. headers in the east and west galleries thus form a loop. Figure 17 shows one of the pipe galleries.

A fairly complete system of metering has been installed to facilitate and improve the operation of the plant. This includes a set of recording instruments in the meter room of the chemical building and several indicating units in the pump and chemical feed rooms and in the filter building.

The laboratories are located on the second floor adjacent to the dry chemical feed room and include two chemical laboratories for general analytical and research work; a bacteriological laboratory supplemented by a media

preparation room; and a fuel testing laboratory for the analysis of coal, oil, etc., used in the water works.

During the normal heating season, the plant is supplied with steam for heating purposes from North Point Pumping Station, approximately 1¼ mi. away.

The buildings are designed in the medieval style modified to fit modern conditions and the special requirements of a water purification plant, with a marked vertical expression to contrast with the horizon line of Lake Michigan. Material for the exterior is a hard limestone, quarried in the neighborhood of Milwaukee, and the roofs, where not flat, are covered with variegated red Spanish tile.

Except where noted below, practically all walls are lined with glazed tile. The windows are either of wrought iron or aluminum and the doors of hollow metal. In the filter building glass block windows are used. All flat roofs are of concrete, covered with an insulation and composition roofing.

The chemical building has a structural steel skeleton because of the heavy loads superimposed by the steel storage bunkers and other chemical storage. Steel columns and floor beams below the second floor are encased in concrete. All floors throughout the building are built of concrete with rubber tile finish in the administrative offices and chemical laboratories. The walls of the main lobby are lined with Mankato stone and the floor is green marble and green slate in 12-in. squares, laid checker pattern.

The walls of the pump room are lined with terra cotta in two shades of tan, and the floor is red quarry tile. The steel roof trusses and crane runways are supported on steel columns embedded in the masonry walls.

In the service building the steel roof trusses are supported on masonry walls, and the floors are concrete throughout. A solid wall separates the garage from the rest of the building.

The walls of the operating aisles in the filter building are lined with terra cotta in shades of light green. The floor is tile of a variegated reddish-brown color. Walkways around filters are built of concrete.

No piling was required to support any of the structures. Instead, after the site was dewatered, the bottom of the lake near shore was excavated to the required depth. Over the east half of the site, where the lake bottom was below the footings, sand was placed to support the structures.

The buildings are set in a broad landscape of lawns and planting with Lake Michigan on three sides. The coagulation basins and reservoirs to the north and south of the buildings are covered with earth, forming terraces which offer welcome relief as they rise above the general level. The wide expanse of beautiful lawns above these underground structures, where the soil is too shallow to permit anchorage of plants in the prevailing high winds, adds materially to the attractiveness of the site.

The bulk of the planting, with the exception of the "foundation planting," is on the slopes which were made flatter for that reason. There are a few groups of trees and evergreens, but most of the shrubbery is in broad masses to conform to the prevailing horizontal lines and to establish the proper proportions between the size of the buildings and the expansive areas of lawn and water. This type of planting is used also because it pro-

vides self-protection against the severe winds which sweep the site. An underground sprinkling system is installed over the entire site.

Problems Associated With the Water Purification Plant

When the water purification plant was planned and constructed, many individual problems were encountered. The first of these was the capacity of the plant. In deciding this question, consideration was given to the capacity required at the time the plant would be placed in service and the capacity that probably would be required about 15 yr. later. Then, too, since it had been decided to build the plant on the lake shore in a high-class residential district, some consideration was also given to the undesirability of subjecting the neighborhood again at an early date to the nuisance of heavy trucking which had to be concentrated on two boulevards leading to the entrance to the park on top of the bluff. The site of the plant is inaccessible from three sides. Indications in 1944 are that the present capacity of the water purification plant will suffice for about 20 yr.

The site was selected because of the location of the intake tunnel and the shore shaft. It would not have been economical to locate the plant elsewhere because additional land tunnels would have been necessary to conduct the raw water to the plant and the filtered water from the plant to the major pumping stations. Another advantage is that the site makes it possible to dispose of the wash water readily.

While at first the preliminary plans called for locating the plant near the foot of the bluff in the park, it was decided later to build it farther out in the lake so as to give the buildings and the grounds a more attractive setting. Its present location also makes it possible to extend the drive along the lake to the north at low level.

When consideration was being given to the steel revetment wall, a question arose concerning the type of sheet piling to use and the depth to which it could and should be driven. To solve this problem a contract was awarded for 75 ft. of revetment wall to be built of three different types of sheet piling, each type to be used for a length of 25 ft. The location of the test section was selected so that when it was completed it would become part of the wall around the site.

During the driving of each length of piling, records were kept of the weight of the hammer used, the number of blows per unit of penetration at various elevations, the labor involved and any difficulties encountered because of the large number of boulders embedded in the bottom of the lake. It was found that the driving was fairly uniform up to a penetration of about 6 ft. Beyond that the driving became more difficult and costly. The conclusion drawn from this work was that the plans and specifications for the entire revetment wall should require all-steel piling to be driven with a 6-ft. penetration. This work also enabled the city to select that type of piling which the tests showed would be the best. This was of the arch-web continuous-interlock type with a thickness of $\frac{3}{8}$ in. in the web and side walls, a weight of 31 lb. per sq.ft. of wall, and with a 15-in. center-to-center of interlocks.

When the preliminary layout of the plant structures was made, it was appreciated that the cost of the project would be affected by the area of the site required. It was decided, there-

fore, to use the double-deck type of coagulation basin because it provides double the settling capacity for a given ground area involved and also because it was possible to place the bottom of the coagulation basins at the elevation of the bottom of the clear well below the filters.

A study was also made of the probable upward pressure on the coagulation basins and clear water reservoir with a high lake level. The facts involved were given careful consideration and influenced the depth of earth fill placed on top of these structures.

When the furnishing of electric power was considered, it was decided that power be supplied from two different power plants, through twin underground power lines run in separate duct systems well separated from each other. The lines terminate in the city-owned sub-station just in the rear of the pumping station.

To take care of any surge that may take place in the tunnel it was deemed advisable to build a surge-relief chamber in lieu of permitting the water to flow out through small shafts or manholes onto the station grounds. In case of a sudden interruption of power at the pumping station, the check valves will close, and the surge from the intake tunnel will cause the water to rise in the shaft over the raw water tunnel and enter the surge chamber. In this way the chamber supplements the intake shore shaft and relieves the pressure due to the surge.

A somewhat complicated problem arose in planning and making the connection between the 12-ft. raw water tunnel and the old shore shaft because the elevation of the invert of the tunnel is about 39 ft. below the level of the water in the shore shaft. This was accomplished by using a steel cylinder 31 ft. high and 12 ft. 6 in. in diameter, on the inside of which there was bolted a steel bulkhead 12 ft. high and curved to fit the circumference of the cylinder. The length of the arc of this plate was 10 ft. The location of the steel bulkhead on the inside of the cylinder was such that when the cylinder was later placed on the inside of the shore shaft the plate was opposite the opening to be made for the raw water tunnel connection. After divers, working from a movable platform or cage lowered into the shaft, had cut several circular grooves into the concrete wall of the shaft on the inside at definite elevations in relation to the elevation of the raw water tunnel, the steel cylinder was lowered and grouted into place. The bottom of the steel cylinder thus permanently grouted into place on the inside of the shore shaft was about 10 ft. below the invert of the 12-ft. raw water tunnel. It was then possible to cut into the old shore shaft from the outside and make the physical connection between the tunnel and the shore shaft. When the concrete from the shaft was removed from the outside, the steel cylinder which had been rigidly grouted into place was exposed and prevented any water from passing out of the shaft into the tunnels. When the tunnels and the connection with the shaft were completed, that portion of the steel cylinder exposed to view on the inside of the tunnel was cut away, thus exposing the steel plate which had previously been bolted to the inside of the steel cylinder. On completion of the plant, divers were again lowered into the shore shaft by means of the movable cage, the steel plate was unbolted and removed, and water was permitted to flow from the shore shaft into the raw water tunnel.

When the pipe galleries between the

filter boxes were planned, it was decided to provide ample space between the filter boxes. A survey of many filtration plants then in existence disclosed that in practically all of the pipe galleries a small space had been provided for the piping, valves and other accessories apparently making it difficult to maintain or remove any unit in case of repairs. It appeared remarkable that so much equipment could be assembled in the space allotted to it. In the case of the Milwaukee plant it was definitely decided to provide space sufficient to permit the equipment to be easily maintained and removed whenever necessary.

In planning for the equipment in the pipe galleries it was decided, after due consideration, to set the rate controllers with the center line of flow vertically downward. This is contrary to the practice that had been followed in other filtration plants.

Before the capacity of the individual pumps in the low-lift station was decided upon, a careful study of the pumpage rates at the major pumping stations was made so as to select pumps with capacities that would be operated efficiently. This accounts for the four 50-mgd. pumps and the one 75-mgd. pump. With this arrangement the pumping capacity used can be varied by 25-mgd. increments.

It was also finally decided to install five 36-in. diameter valves in the wash-water headers in the pipe galleries and locate them so that it would be possible to cut out of service any one-quarter, one-half, or three-quarters of the filters. This facilitates maintenance and repair of equipment.

The problem of heating was solved by supplying the plant with steam from North Point Pumping Station through an underground steam main. Under ordinary conditions it would not be economical to conduct steam the distance here involved (1¼ mi.), but since the city owns the North Point Pumping Station and has the station staff on its payroll for other necessary work, an analysis of the problem showed that it was more economical to use the steam from North Point Pumping Station than to provide heat by some other system.

The item of condensation in the filter building was quite complex, and a satisfactory solution could not be found during the planning of the building. It was, therefore, decided to install windows and glass at the doorways leading to the outside without special materials to prevent condensation, and then later make a study under operating conditions. This procedure was followed and later resulted in the installation of glass blocks in the windows and the construction of the glass vestibules just inside the entrances.

Considerable time was spent by the architectural staff in planning the structures above the ground. Several different layouts of the buildings were made, and many architectural perspective drawings were prepared, and from all of these the one used in the construction was selected. This is one item that was considered of great importance because of the location of the plant.*

Pumping, Consumption Statistics

The records thus show that the several facilities of the Milwaukee Water Works were expanded materially since 1874 when the initial plant was com-

* A general view of the Milwaukee Filtration Plant appeared in this JOURNAL (August 1944, p. 830) and as a frontispiece in the "Manual of Water Quality and Treatment."

pleted. During the 70 yr. that have passed many interesting problems were encountered, and particularly so during the past 20 yr. because of the rapid growth in population, annexation of lands with high elevations, and the demands of the industries and of the suburban communities served by the city. Some of these problems were complicated by the attitude taken by the suburbs which at times demanded improved service and then at other times planned, or at least threatened, to build a water works. Several neighboring towns also demanded service and their demands were approved by the Public Service Commission only to be later denied by the courts. This uncertainty over a period of years seriously complicated the planning of service to consumers most distant from the pumping stations.

In order to solve the various problems encountered, many surveys and studies were made. One of these is the study of the demand for water over a period of years and the probable demand in the future. When these studies were started, old records on file in the pumping stations were analyzed and the results tabulated. A considerable amount of work was involved because the pumping station records did not show for the earlier years the amount and rate of bypassing from the high-service to the low-service districts. Consequently, individual pump operations and Venturi meter charts had to be analyzed. The data thus obtained were set up in the form of graphs for the low-service district, for the high-service district, and for the system as a whole.

The graph for the low-service district (Fig. 18) shows that the annual demands in this district have not changed materially and that the pumping capacity provided is ample for many years to come. The graphs for the high-service district (Fig. 18) show a different situation. The trend of the several curves is upward and indicates that a continued growth can be expected, particularly in view of the fact that the city's outlying districts and some of the suburban communities served by the high-service pumps are not yet built up. One striking fact set forth is the difference between the peak hourly consumption rate and the peak hourly pumping rate brought about by storage in the high-service district of the distribution system. The graphs for the system as a whole (Fig. 19) show the over-all conditions in the demands for water and the pumping capacity installed.

Peak Consumption and Planning Storage

One interesting problem encountered resulted from the rapid growth in the peak use of water. Since about 1920 the use of water for lawn sprinkling has increased due to the shifting of the population from the central congested part of the city to the newly annexed areas and the suburbs where lawns are the rule rather than the exception. Peak use, which in 1920 was less than twice the yearly average daily rate of use, reached a high of more than three times the average rate when considering the city as a whole, and four times the average rate when considering the high service only.

Up to 1930, the pumps serving the high-service area met the widely fluctuating load without the assistance of any stored water in the area. This resulted in poor pressure in some of the outlying high areas during the peak consumption hours. The older portion of the city, which is largely within the

low-pressure area, continues to have a peak rate of use about twice the annual average rate of use. In this area the 25-mil.gal. reservoir supplies part of the demand during the peak hours.

The addition of pumping capacity at the major stations could not alone correct the poor pressures in the high-service district. The high velocities of the water in the feeder mains during the peak consumption hours had to be reduced by increasing the feeder main capacities or by storage in the distribution system near the areas experiencing the poor pressures. Sprinkling regulations were considered but only as a temporary measure.

The studies made led to the introduction of storage in the distribution system, and in 1930 the first $1\frac{1}{2}$-mil.gal. elevated steel tank was installed in a park near one of the distant areas experiencing the poor pressure. After due consideration of the conditions, the overflow of the tank was placed 22 ft. below the static pressure elevation to permit the tank to be filled overnight. By means of a time control switch the tank is connected to the distribution system just immediately before the evening peak consumption hours, and the entire capacity is made available for the period when needed most.

When this tank was placed in service, it was found that the capacity of the tank was not sufficient to boost the pressures satisfactorily for the entire evening sprinkling peak. It was found that the rate of flow during the first year's operation was as high as 750,000 gal. per hr. so that on a very hot day the tank would suffice for a 2-hr. period. It was also found that this condition was aggravated by one of the suburbs which filled its elevated tank during the sprinkling period. Limiting the area of influence of the tank would have permitted its effect to be spread over a larger period of time, but a separate pressure area around the tank was considered undesirable.

The following year the second $1\frac{1}{2}$-mil.gal. elevated steel tank was installed near another high-service area which experienced poor pressures during the peak consumption hours. This tank also improved pressures in its vicinity, but again the capacity of the tank was not sufficient to bridge the entire sprinkling period.

A study of the consumption curves of the demand on hot days for a period of years disclosed the fact that the amount of water used for sprinkling lawns was not particularly excessive, but the rate at which it was used for this purpose was quite high. Plotting the consumption curves of the demand on peak days for a number of years on one sheet of paper graphically illustrated the annual rate of growth in consumption for each hour of the peak day. It was found that the annual rate of growth in water consumption for the morning hours did not equal the rate of growth for the late afternoon and early evening hours. The distribution system could adequately supply the consumption demand on peak days for many years to come except for the hours from 4:00 P.M. to 8:00 P.M.

A further study of the area under the consumption curve led to the conclusion that the amount of water needed for the evening sprinkling peak at that time was 6 mil.gal. more than the peak demand of any other similar period of the peak day. In other words, if 6 mil.gal. of water could be injected into the distribution system at the necessary rate (gallons per minute) the pumps at the major pumping stations need supply water at no

higher rate during the evening sprinkling hours than during the morning hours. Since the morning peak rate of consumption could be supplied by the pumping stations and the distribution system with minor additions, it was considered logical and advisable to store more water during the off-peak hours and use this storage during the peak hours.

The rates of consumption for the peak day in 1920 and for the peak day in 1930 in the high-service district are shown in Fig. 20. It will be noted that the growth in the rate of demand during the peak period was higher than the growth in the rate of demand during the morning hours. It will be noted also that the storage required to meet the peak demand in 1920 was 1 mil.gal. and in 1930 was 6 mil.gal.

Figure 20 also shows the estimated demand for 1940 and for 1950 and the amount of storage that would be required during those years and also the demand experienced in 1934 and 1936. The curve for the demand that was experienced in 1940 is not included. This curve would fall slightly below the curve for the estimated demand in 1940 and for the sake of clarity is omitted. The estimates were made in 1931 and indicate that the amounts of storage for the later years were over-estimated.

Several plans for storing water were considered. One plan consisted of installing a sufficient number of elevated tanks on steel towers. Another plan considered was storing water in large standpipes at several high elevations near the city limits. A third plan consisted of storing water not too far from the center of consumption and, by means of booster pumps, forcing the water into the distribution system during the peak hours. The last plan was adopted.

The site chosen for the booster station is about 7 mi. from the major pumping stations and about midway between the two elevated tanks. Large-diameter mains connect the site with the major pumping stations and the two elevated tanks. These large feeder mains permit the rapid filling of the two 6-mil.gal. ground storage tanks at this site and also permit high pumping rates by the booster pumps. The operation of the booster station, midway between the two elevated tanks, slows down the rate of flow from the tanks and enables them to bridge the entire sprinkling peak without going dry. Then, too, the booster station is not too far removed from the center of water consumption so that excessive losses are not experienced in getting the water from the booster station to the areas of high consumption.

Figure 21 shows the rate of consumption and the rate of pumpage for the high- and low-service districts for the day of peak consumption in 1936, the highest peak consumption on record. It also shows the amount of water that was taken from storage, namely 9½ mil.gal. to supplement the amount furnished by the major stations during the evening sprinkling period.

Figure 22 shows the hydrant pressures at one of the two high elevations on the south side in the high-service area taken in 1928, and it will be noted that the pressures dropped to zero during the evening sprinkling period. This occurred before any storage had been installed. The peak high-service consumption rate at that time was 116 mgd. The figure also shows the pressures obtained at the same location after the storage had been installed. The peak high-service consumption rate at this time was 224 mgd. It is thus seen

that the low pressures at the point of high elevation were appreciably raised by the storage in spite of the fact that the peak consumption rate in the high-service district was practically doubled.

Pitometer Surveys and Pressure Readings

In order to plan the size and location of feeder mains, the city carries on a pitometer survey and obtains pressures in the distribution system from about June 1 to September 15 each year. Pitometer readings are taken at critical points in the system to determine the variations in the rates of flow in the larger feeder mains and to record the change in amount and direction of flow in certain mains when the elevated tanks and booster pumps are in operation.

Each summer, also, pitometers are placed on the feeder mains supplying the suburbs so as to obtain a graphical record of the variation in rate of flow to these consumers. This information has been helpful in planning the feeder mains supplying the suburbs and recently proved to be of great value when the city contended before the Public Service Commission that the suburbs were not entitled to a preferential rate because they were large water consumers. While the suburbs purchased large quantities of water, the pitometer records showed them to have a high peak rate of use. Figure 23 shows a typical set-up of an enclosed pitometer, and it is to be noted by the location of the manhole cover that the unit is set some distance away from the feeder main. Most manholes are located in city streets, and placing the instrument above the manhole would be hazardous and obstruct traffic. Figure 24 shows the pitometer recorder and tubing which connects the recorder to the main.

The pressure records are obtained by means of recording pressure gages attached to hydrants. The gage is enclosed in a strong metal box which is firmly bolted to the back of the hydrant. A flexible tube connects the gage to the barrel, thus permitting all nozzles to be available for use without removing the recording pressure gage. A typical installation of an enclosed pressure gage bolted to a hydrant and the flexible tube connected to the barrel is shown in Fig. 25. The pressure gage itself is shown in Fig. 26.

The gages are placed at the same critical locations each summer, thus providing a continuous pressure reading for the summer months at each of the chosen locations. The record of the variations in the daily pressures,

TABLE 2

A Test No.	*B*	*C*
1	120	109
2	121	99
3	129	110
4	112	103
5	124	87
6	127	87
7	108	90
8	115	88
9	127	87
10	126	105
11	121	>80
12	111	86
13	124	88
14	122	>80
15	125	103

especially on peak consumption days, and the progressive lowering of the annual minimum pressures due to increased consumption are very useful in determining the need and direction of additions to the distribution system. The pressure records thus obtained

also graphically show the extent of the influence of the tanks.

A recent pitometer survey of the larger mains in the distribution system showed them to be in good condition. In "loss-of-head" tests made on mains 30 to 54 in. in diameter, the "C" value in the Hazen-Williams formula was found to be as shown in column B of Table 2. The corresponding "C" value from Hazen-Williams tables for mains of the ages used in the tests are shown in column C. In each case the "C" value determined by the survey was higher than the theoretical "C" value obtained from the Hazen-Williams tables.

Jointing Compounds

Some time ago an investigation was made of several jointing compounds to determine: (1) the extensiveness of their use in water mains; (2) the general nature of each material; (3) the ingredients contained in each by chemical analysis; (4) the percentage decrease in sulfur content through heating and melting; and (5) the melting time required and the pouring temperature for each material. The investigation also included a field test to determine the length of time required to take up the initial leakage in the various types of joints and the maximum pressure required to burst the joints. As part of the field test a water main with lead joints was laid to obtain some comparative data with that type of material. Some phases of the investigation will be briefly mentioned.

Historical data and information obtained from various cities disclosed that jointing compounds have been used extensively for many years and that, while in most cases the compounds have been used on the smaller sized mains, some have been used on sizes up to 54 in. Whether this is due largely to the fact that most users have been comparatively small cities which did not need larger mains, or whether there is some reason why engineers prefer to use them on the smaller mains, was not determined. Changes from the use of one compound to another were largely due to cost in some cases, while in others they were due to both the cost and workability of the materials.

The general nature of the several compounds, including a consideration of the kind of containers used by the manufacturers and the effect of kerosene, oil, etc., on the materials, will not be considered in detail here.

A chemical analysis of the compounds is shown in Table 3.

It can be seen that sulfur and sand make up more than 96 per cent of each of the compounds. All three compounds contain practically the same ingredients in slightly different proportions. In one compound the sand used

TABLE 3

Chemical Analysis

Compound A	%	*Compound B*	%	*Compound C*	%
Sulfur	48.46	Sulfur	55.00	Sulfur	60.78
Sand	47.88	Sand	41.56	Sand	36.62
Sodium chloride	1.96	Sodium chloride	0.07	Sodium chloride	0.15
Carbon (by diff.)	1.70	Volatile organic matter (by diff.)	3.23	Other water-sol. matter	1.12
		Other water-sol. matter	0.14	Carbon (by diff.)	1.33
	100		100		100

is laminated while in the others it is granular. Perhaps a simpler explanation of the difference is that the granular sand has a feel of sugar or salt while the laminated sand has a feel of face powder or flour.

The percentage of decrease in the sulfur content due to heating was determined by analyzing the cones removed after the joints had been poured in the field tests. The decrease in the sulfur content is as follows:

Compound	*Sulfur Content of Original Compound—%*	*Sulfur Content of Cone After Pouring—%*	*Percentage Decrease in Sulfur*
A	48.46	46.16	4.75
B	55.00	54.50	0.91
C	60.78	50.29	17.25

In this connection it is of interest to note that one of the cities in this country which had unsuccessfully used one of the earlier jointing compounds reported that every analysis of the disintegrated joints showed that the sulfur content of the original material had been materially reduced. A sample analysis of a disintegrated joint showed the sulfur content to have been decreased two-thirds, or 67 per cent.

The laboratory tests also disclosed that each compound has a temperature range within which it is of proper consistency for pouring. Above and below this range thickening occurs, preventing pouring. The melting time required and the temperatures at which the materials were satisfactorily poured in making tests in the laboratory were as follows:

Compound	*Melting Time Required—min.*	*Pouring Temperatures*
A	$25\frac{1}{3}$	266° F. and 282° F.
B	$19\frac{1}{3}$	284° F. and 311° F.
C	$24\frac{1}{3}$	266° F. and 302° F.

The field test on the jointing compounds and lead was made with 12-in. water mains of three lengths each (Fig. 27). One end of each main was plugged and the other end was capped. A different jointing material was used for each line. The ends were securely strapped and the lines rigidly blocked at the center to prevent lateral movement. The lines were fed from the city supply through $\frac{1}{2}$-in. copper tubing so arranged that the individual lines would be gated off from each other. A $\frac{1}{4}$-in. plug was tapped into the top of each line near the plug ends to permit the escape of air and also to permit the insertion of pressure gages.

The pipe used was uniform with well-formed beads on all spigots. All bells and spigots were thoroughly cleaned with a wire brush before being driven home. Line and grade were given for each line and wooden blocks were used to attain the proper grade and rigidity. The melting pots were thoroughly cleaned with wire brush and chisel for use with the different compounds. One-half-inch braided hemp, 46 in. long, was used at all joints. After the hemp was driven home with the aid of yarning irons, the depth of each joint was measured to insure a proper depth of joint which in all cases averaged between $2\frac{3}{4}$ and 3 in.

When the lines were completed, the water was turned on and the pressure varied between 60 and 70 lb. The lines were under this pressure during the entire test except for short periods when the valves between the supply line and the mains were closed and pressure-loss tests were conducted. The joints were exposed to the sun on two days before the lines were backfilled. The one end of each line was left uncovered to permit the conducting of pressure-loss tests, but heavy timbers

were placed across for protection when such tests were not being run.

During a period of about 60 days, 23 pressure-loss tests were made. The ¼-in. plugs in each line near the plug ends were removed and pressure gages inserted. The valves on each line were then closed, thus isolating the individual lines, and the pressure gages were read at 5-min. intervals for the duration of each pressure-loss test. It should be noted that the method is so sensitive an indicator of leakage that a very slight leakage will result in a large pressure drop within the line itself. Therefore, a large pressure drop does not necessarily mean an enormous leakage but is only an indicator for comparison of initial leakage in the various lines.

The pressure loss in each line, after having been disconnected from the city main for one hour at the time of each individual test, is shown in Fig. 27. It will be seen that the initial pressure loss in each line was not the same and that the pressure loss in each was gradually reduced. At the end of 38 days there was little difference in the pressure losses, and at the end of 62 days when a test was made all three lines maintained pressure without any loss. It is very likely, however, that this condition occurred previous to this test and this would have been established had more intermediate readings been taken.

A final field test was made to determine the maximum pressure which could be withstood by the various types of joints including the lead joint. All the joints were uncovered to permit observation. A hand pump was inserted into the feeder main to obtain the necessary pressures. Each of the four water lines was tested separately by valving off the other three. In order to measure any elongation which may have occurred in the line when it was under high pressure, a string was stretched across each end of the lines and a chalk mark was made where the string crossed each pipe. Thus, any elongation of the line would result in throwing the chalk mark off the string and this variation could be measured. An observer was stationed at each joint to note the action of the joint under the various pressures.

The test was begun with a 200-lb. pressure, increased to 500 lb. in 100-lb. increments, then a 50-lb. increase, and then the pressure was increased in 25-lb. increments until failure occurred. Each increment of pressure was maintained for approximately 3 min. to permit the line to adjust itself to the new pressure.

In the case of one compound one joint became moist at a pressure of 200 lb. At 500 lb. the moisture increased and at 600 lb. the joint began to drip very slowly. No further change occurred up to 950 lb. when the cap at the end of the line blew out. Another joint in this line remained dry up to a pressure of 550 lb. when a slight moisture and slight leak developed. The leakage increased slightly at 500 lb., again at 625 lb. and also at 700 lb. This same joint began to drip at 950-lb. pressure when the cap blew out.

In the case of the second compound one joint became moist at a pressure of 200 lb. At 550 lb. the joint dripped slowly and this condition continued until the cap at the end of the line blew out at 700 lb. Another joint became moist at 200 lb. of pressure and leaked slightly at 300 lb. The leakage increased at 500 lb. when the joint began to drip slightly. At 550-lb. pressure the dripping increased, and water squirted momentarily out through a

radial crack. At 575 lb. the dripping increased to a small stream, and then at 600 lb. the dripping decreased. At 675 lb. the joint dripped steadily and developed into almost a stream. This condition continued up to the final pressure of 700 lb.

In the case of the third compound a slight moisture appeared on top of one joint at 200-lb. pressure, and this developed into a slight leakage at 300 lb. At 500 lb. the leakage increased and the joint dripped slowly. At 575 lb. the dripping became slightly less and then at 600 lb. the dripping increased. The dripping again increased slightly at 650 lb. and then at 675 lb. The dripping further increased at 725 lb. and then no further change took place until the cap at the end of the line blew out at 800-lb. pressure. Another joint showed moisture on the bottom at 200-lb. pressure and two hairline cracks appeared on top. At a pressure of 300 lb. a slight leakage developed at the top of the joint, and this leakage again increased slightly at 500 lb. At a pressure of 550 lb. the joint began to drip slowly. The dripping increased at 575 lb. and again at 650 lb. No further change occurred until at a pressure of 725 lb. the joint became loose from the bell at the top. This condition continued until the cap at the end of the line blew out at 800-lb. pressure.

In the main laid with lead one joint started to pull out at a pressure of 400 lb. The joint remained dry. At a pressure of 450 lb. the joint pulled out and at the same time the cap at the end of the line was blown off. The second joint remained dry throughout the test, and when the pressure was raised to 450 lb. the joint loosened slightly from the bell.

The changes that took place at the bell end of the main (with the steel plate) and at the spigot end (with the cap) will not be discussed in detail. These were quite similar to the changes in the other joints.

It is hoped that in the near future the department can make a more comprehensive investigation, one that will include a physical examination of the first mains laid with jointing compounds, the effect of settlement, and also the influence of the reduction in the sulfur content due to heating and melting of the compound.

Standard Hydrants and Gate Valves

The department has also given special consideration to the hydrants and gate valves used in the distribution system. Until 1932 it had installed three different makes of hydrants and found them to be wanting in many ways. Consequently it made a study of the hydrants on the market, tested several of them, and then prepared plans and specifications for a new type of hydrant, known today as the "Milwaukee" hydrant. This standard hydrant includes a positive metal tube drain valve, removable main valve and separate bonnet, nozzle and barrel sections to facilitate the dismantling and repairing, and alemite greasing equipment to improve the operation. The hydrant is also streamlined with curves to reduce friction losses and has a larger full-length and size barrel than the earlier type hydrants.

Gate valves, in sizes from 2 to 20 in., have also been standardized and as soon as conditions permit detailed drawings and specifications for larger-sized gate valves will be prepared. The valves have cast-iron wedge bodies, and are equipped with non-rising stem and non-corrodible bronze working parts. The bodies are equipped

with small shoes to permit vertical storage.

Drawings and specifications have been prepared for tapping valves, tapping sleeves, offset pipes, reduced bends, branches, special reducers, manhole frames and lids, valve and service boxes and various miscellaneous items.

The standardization of all of these items has resulted in better competition and an interchangeability of parts, and has reduced the number of parts required on hand for maintenance and repairs. This has proven to be a decided advantage in the operation of the distribution system.

Future Expansion and Improvements

With the completion of the water purification plant the Milwaukee Water Works is today on a level comparable with the water works of many large American cities. There are, however, some improvements that should and will be made in the near future in order to furnish satisfactory service to all consumers.

One of these immediate improvements is the extension of large feeder mains on the northwest side of the city to raise the pressures during the evening sprinkling period. Provision will also be made for the building of additional storage if this is found advisable. Some mains will be laid elsewhere to reinforce the distribution system.

Another improvement can be made in the high-service district by getting the city of West Allis to take some water from a feeder main north of its limits instead of taking it all as it does now at one location from the mains extending south from the booster station. This will provide better service on the south side within the city and give West Allis a more dependable supply.

Studies are being carried on to determine what improvements may be made at the North Point Pumping Station. The vertical triple-expansion pumping engines at this station vary in age from 24 to 53 yr. and the question arises as to whether a station with motor-driven pumps would be more economical than the existing equipment with its relatively large operating and maintenance force.

It is thus seen that the Milwaukee Water Works has come a long way since 1874. It has been expanded periodically to meet the demands of its citizens and the neighboring municipalities served with water. It will also be expanded in the future, especially in the outlying areas of the high-service district where space is yet available for new homes and industries. This will call for sound engineering with emphasis on the reliability and quality of service so that the water works may contribute to the health, comfort and convenience of the people.

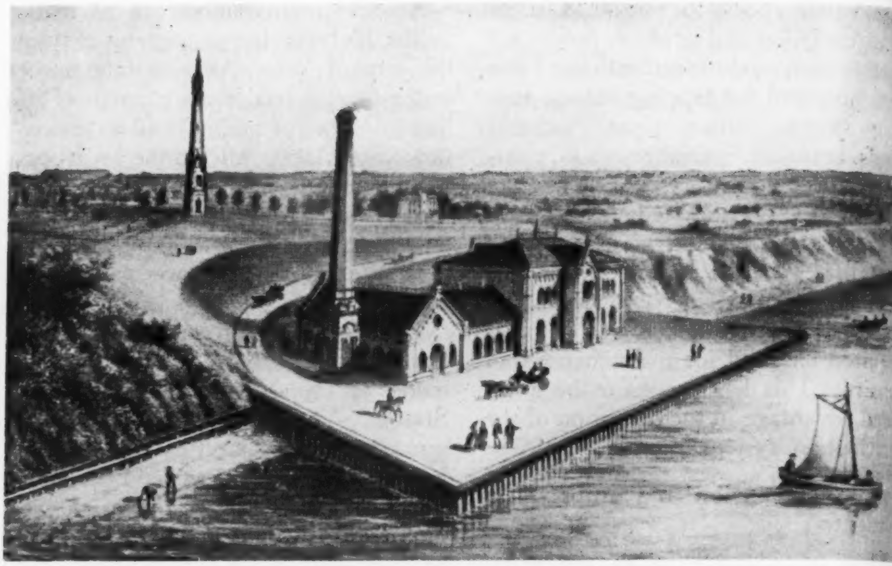


FIG. 1. Milwaukee's Original North Point Pumping Station—1874.

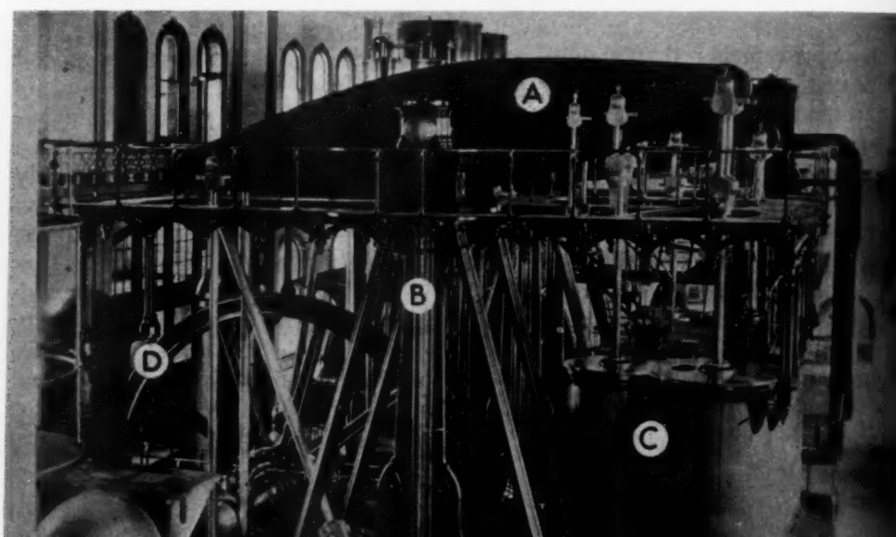


FIG. 2. Striding Beam Compound Engine.

(A) Striding Beam; (B) A-Frame; (C) Steam Cylinders; (D) Flywheel; (E) Water End of Pump.

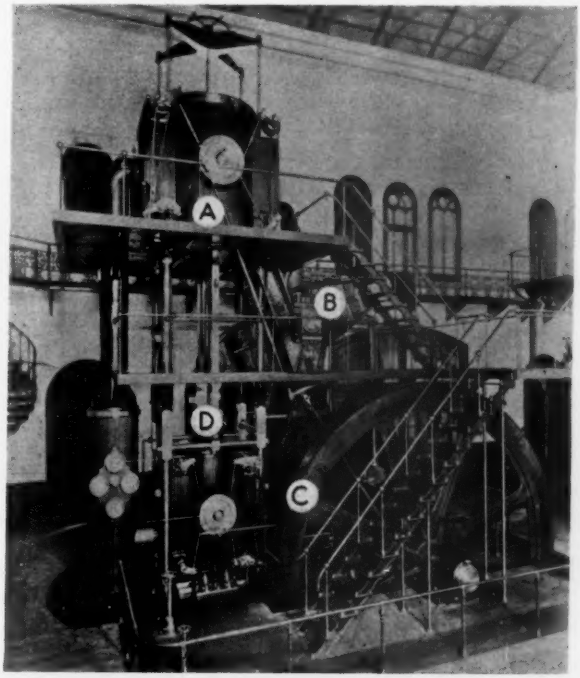


FIG. 3. Steeple Compound Engine.
(A) Steam End; (B) Beam; (C) Flywheel; (D) Piston Rod.

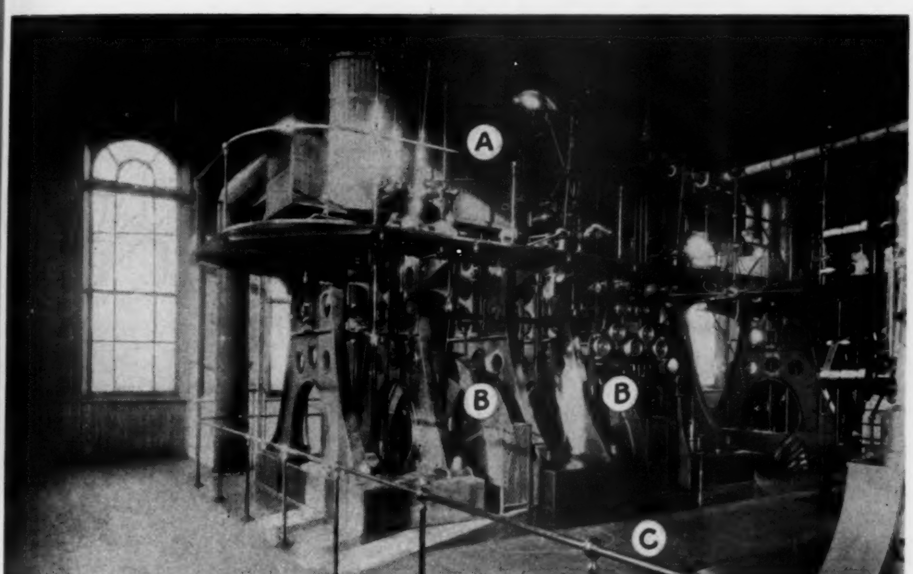


FIG. 4. First Vertical Triple-Expansion Pumping Engine Used in Water Works Service—1887.

(A) Steam Cylinders; (B) Flywheels; (C) Operating Floor.

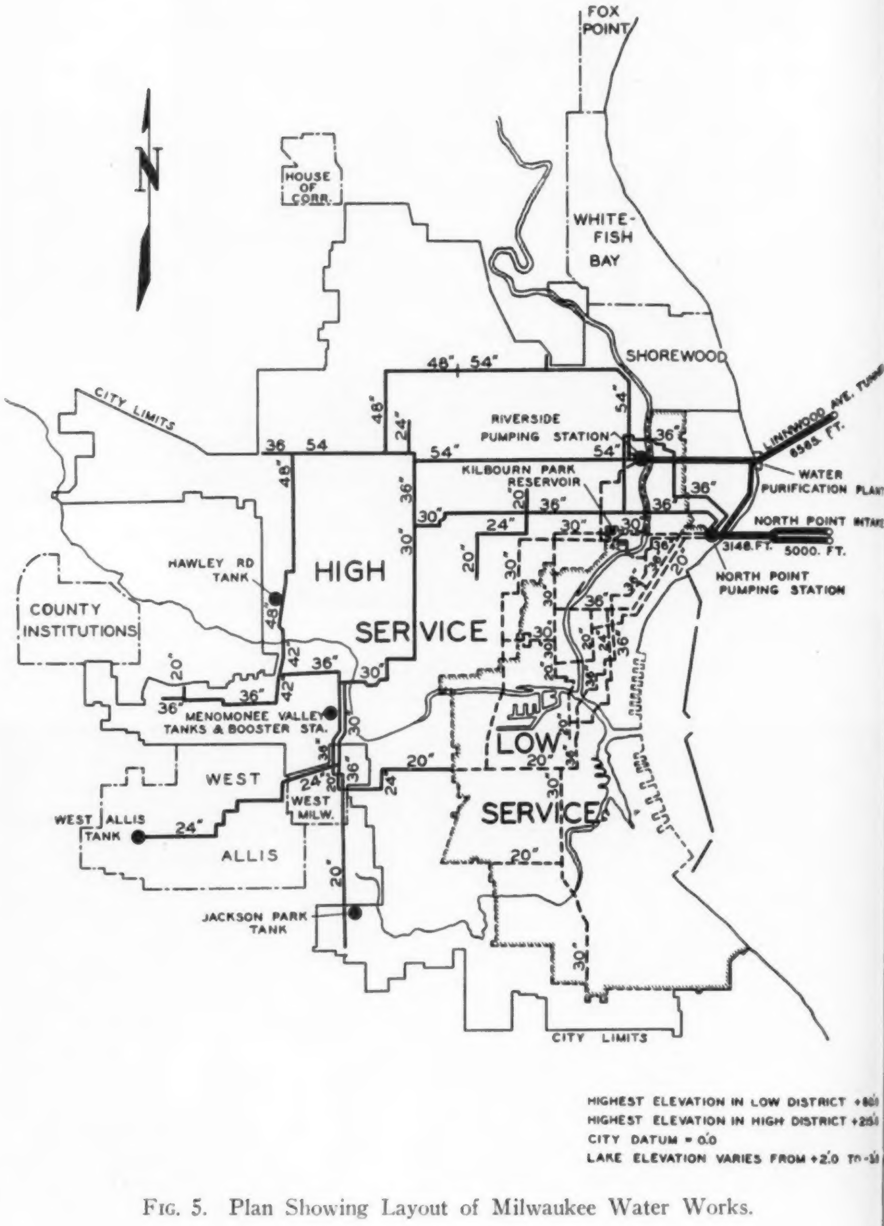


FIG. 5. Plan Showing Layout of Milwaukee Water Works.

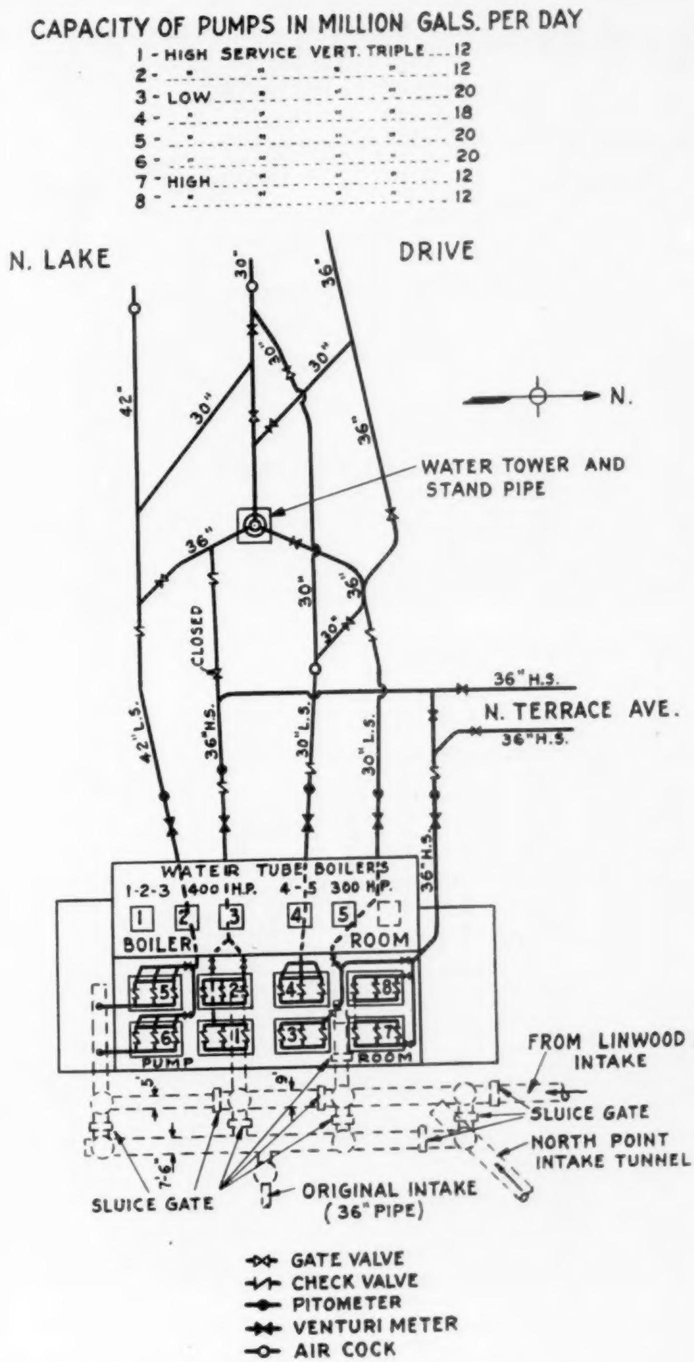


FIG. 6. General Layout of Suction and Discharge Piping at North Point Pumping Station.

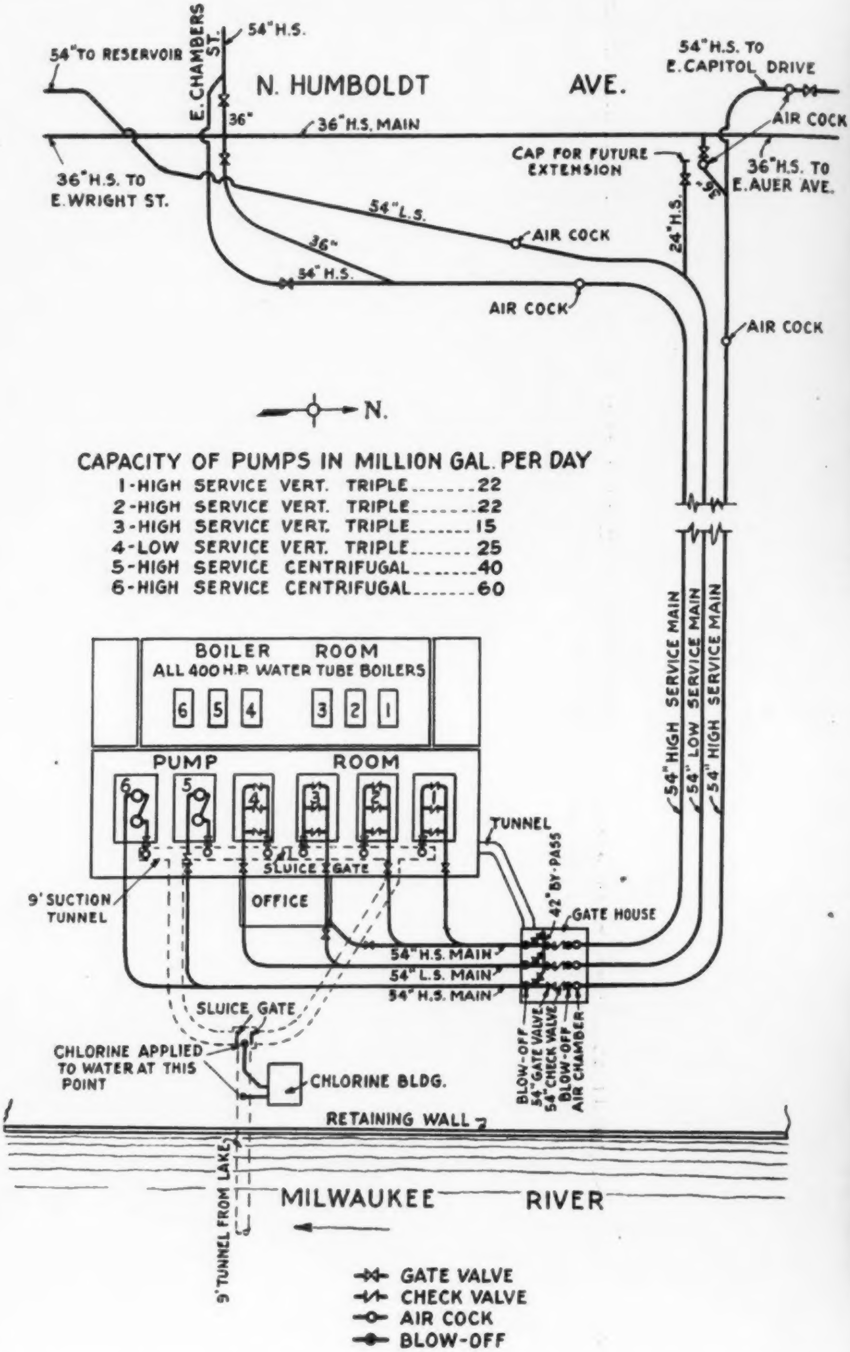


FIG. 7. General Layout of Suction and Discharge Piping at Riverside Pumping Station

FIG. 8. Storage Reservoir in Low-Service District—25-Mil.Gal. Capacity.

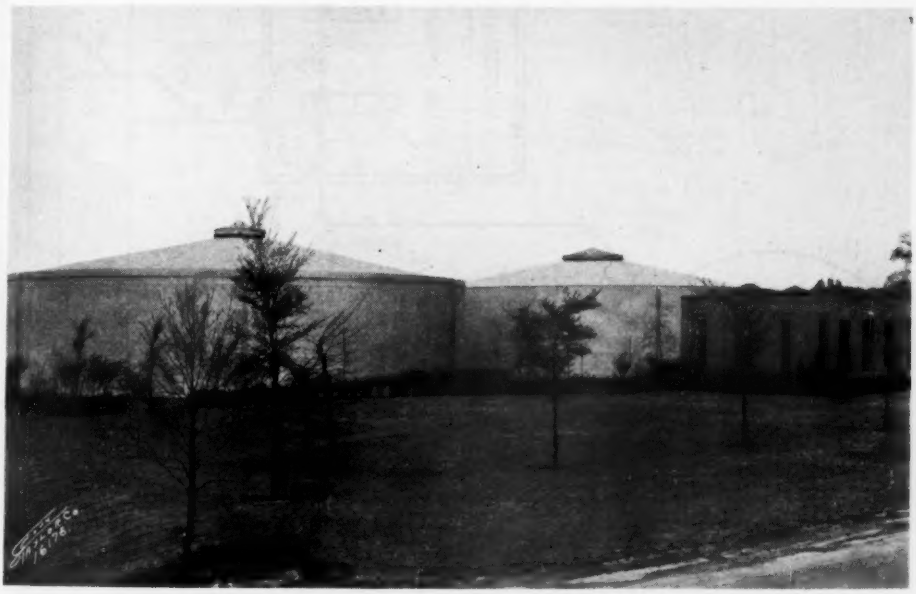


FIG. 9. Ground Storage Tanks and Booster Station in High-Service District. Each Tank, 6-Mil.Gal. Capacity—Booster Station With Three 30-mgd. Pumps.

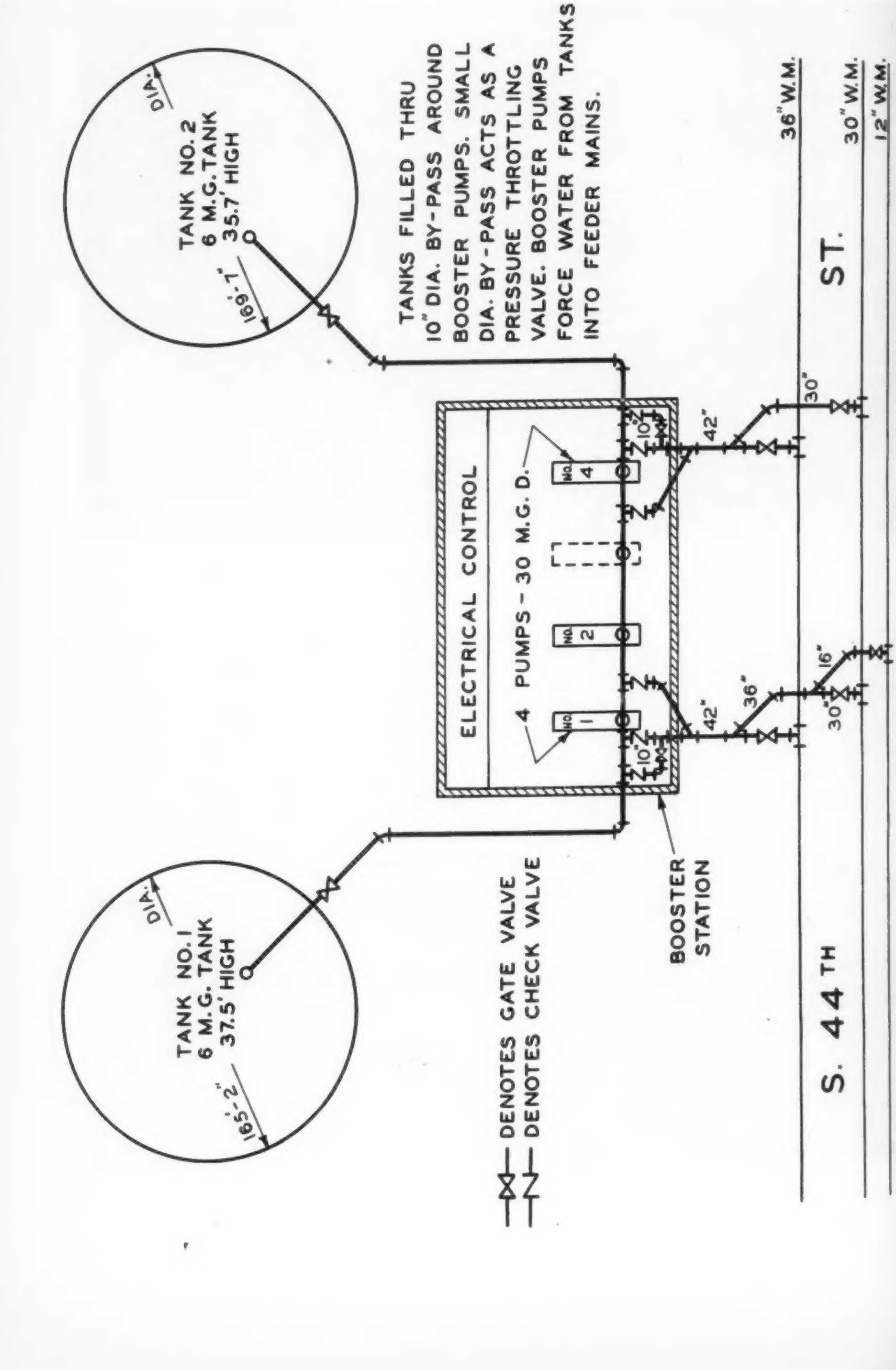


FIG. 10. Piping Diagram of Menomonee Valley Booster Station

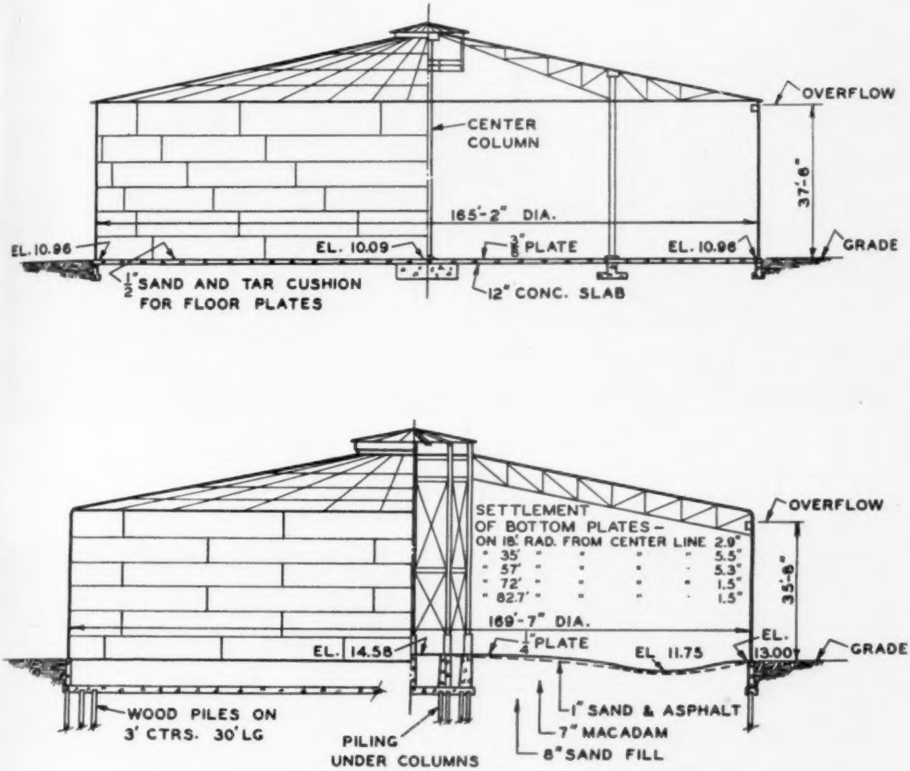


Fig. 11. Foundations of Storage Tanks.

(*Top*) Tank 1—All-Welded, 6-Mil.Gal. Capacity, Concrete Base and Steel Bottom—Settled Irregularly, 4 In. on One Side to 6 In. on Opposite Side.

(*Bottom*) Tank 2—All-Welded, 6-Mil. Gal. Capacity, Piling Under Wall and Center Column and Sloping Bottom.

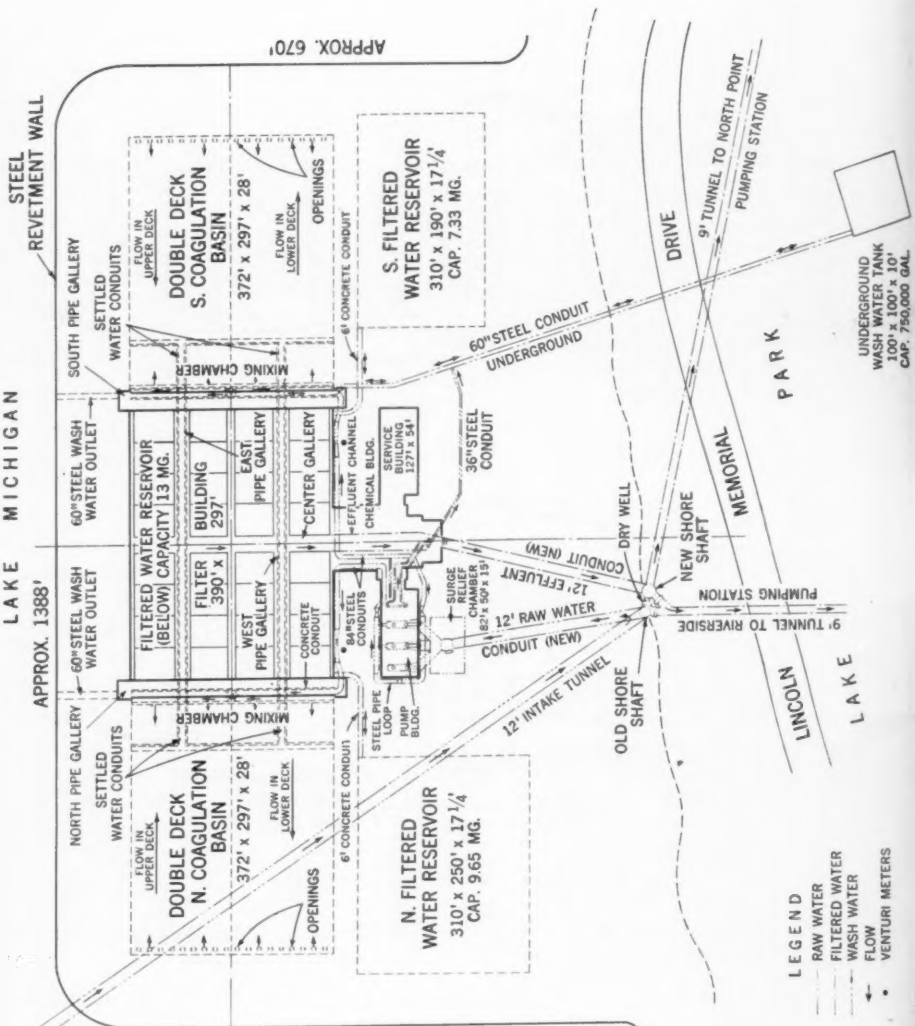


Fig. 12. General Plan of Water Purification Plant

FIG. 13. Pump Room in Water Purification Plant.
(A) Five Low-Level Pumps; (B) Wash-Water Pumps.

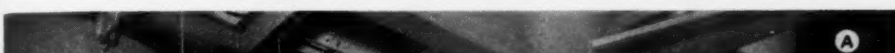


FIG. 14. Chemical Dry Feeder Room.
(A) Storage Bunkers (above); (B) Weigh Hoppers; (C) Scales; (D) Enclosed Electrically-Operated Continuous Feeders; (E) Raw Water Indicators.

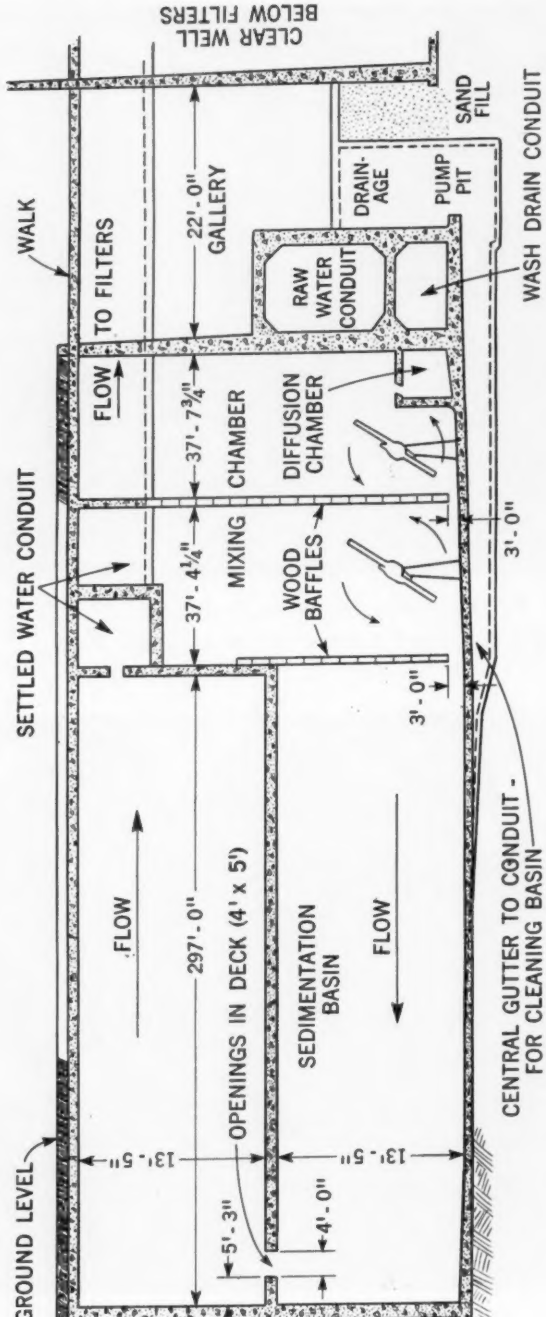


FIG. 15. Mixing Chamber and Coagulation Basin.

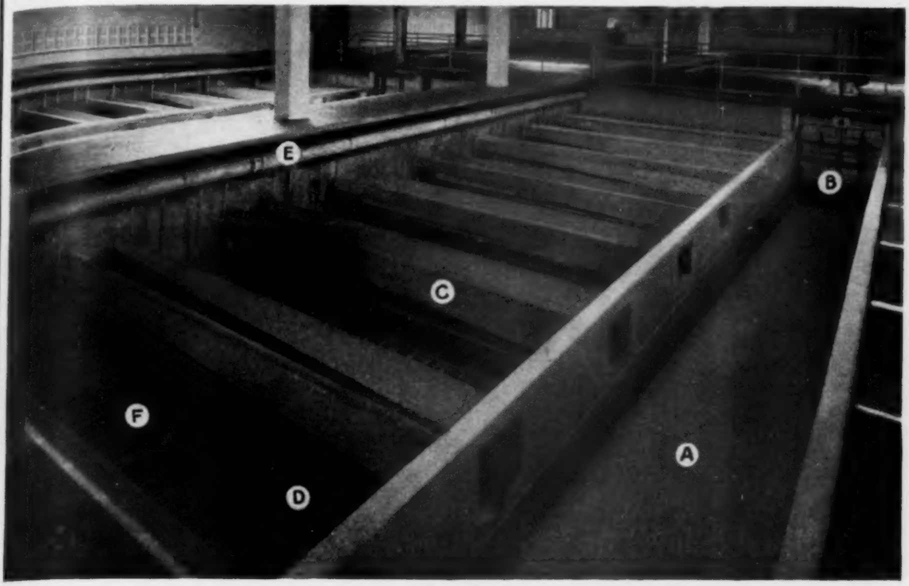


FIG. 16. Filter Unit.

(A) Wash-Water Gullet; (B) Sluice Gate; (C) Concrete Wash Troughs; (D) Sand Bed; (E) Surface Wash Header with (F) Laterals.

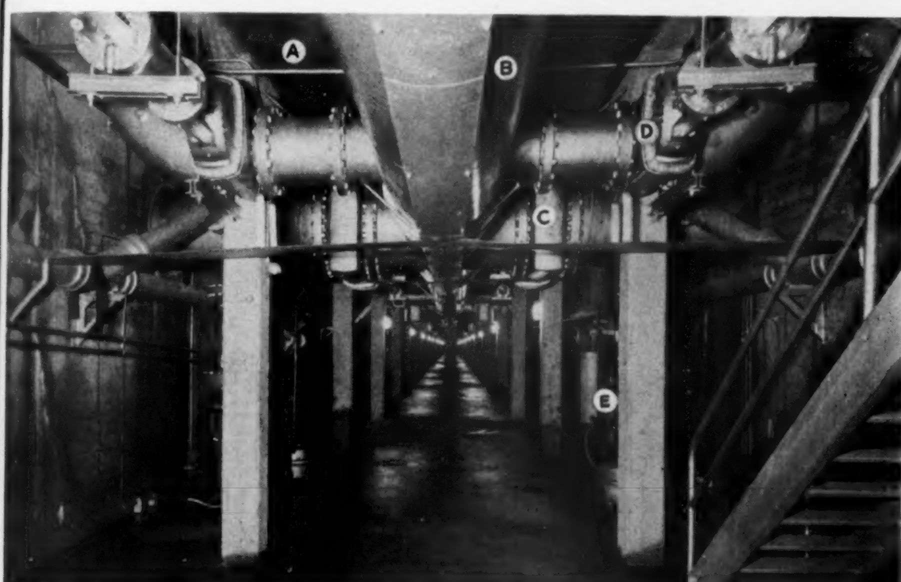
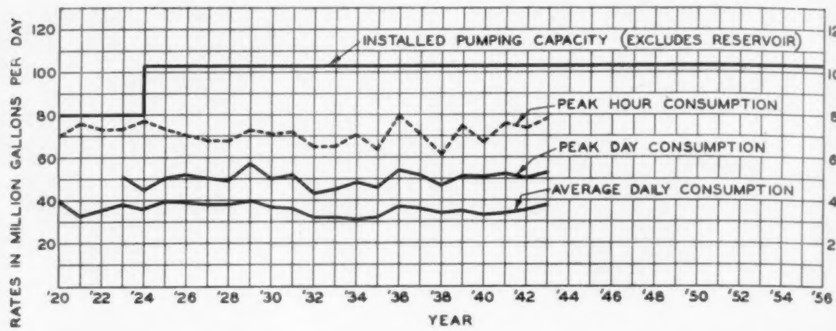


FIG. 17. Pipe Gallery.

(A) Settled Water Conduit; (B) 36-In. Steel Wash-Water Header; (C) 36-In. Wash-Water Valve; (D) 16-In. Surface Wash-Water Valve; (E) Rate-of-Flow Controllers. (Note clearance provided in gallery.)



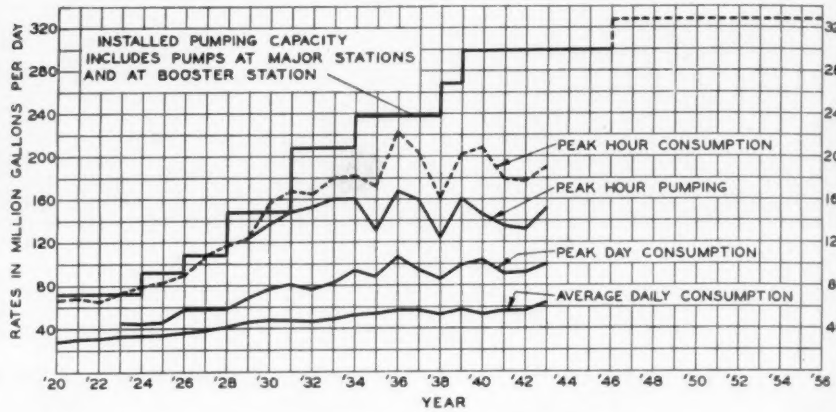


FIG. 18. Rates of Water Consumption.
(*Top*) Low-Service District; (*Bottom*) High-Service District.

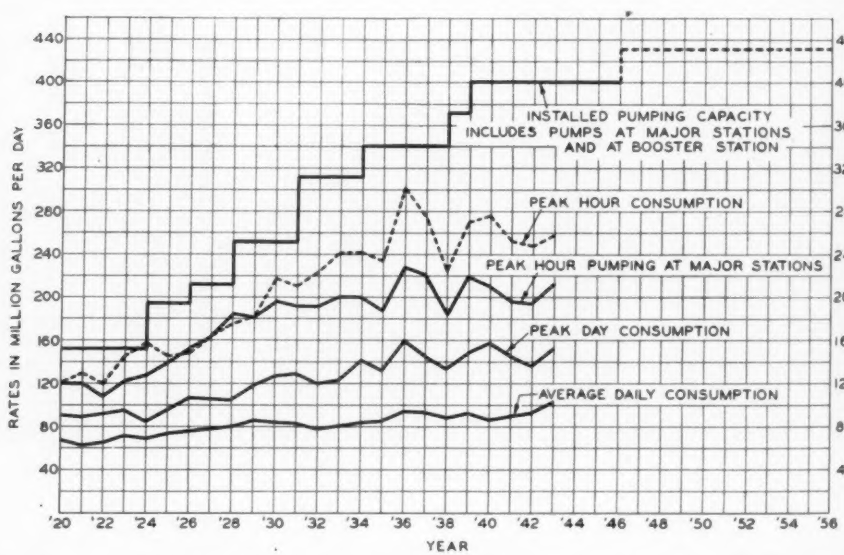


FIG. 19. Rates of Water Consumption in High- and Low-Service Districts.

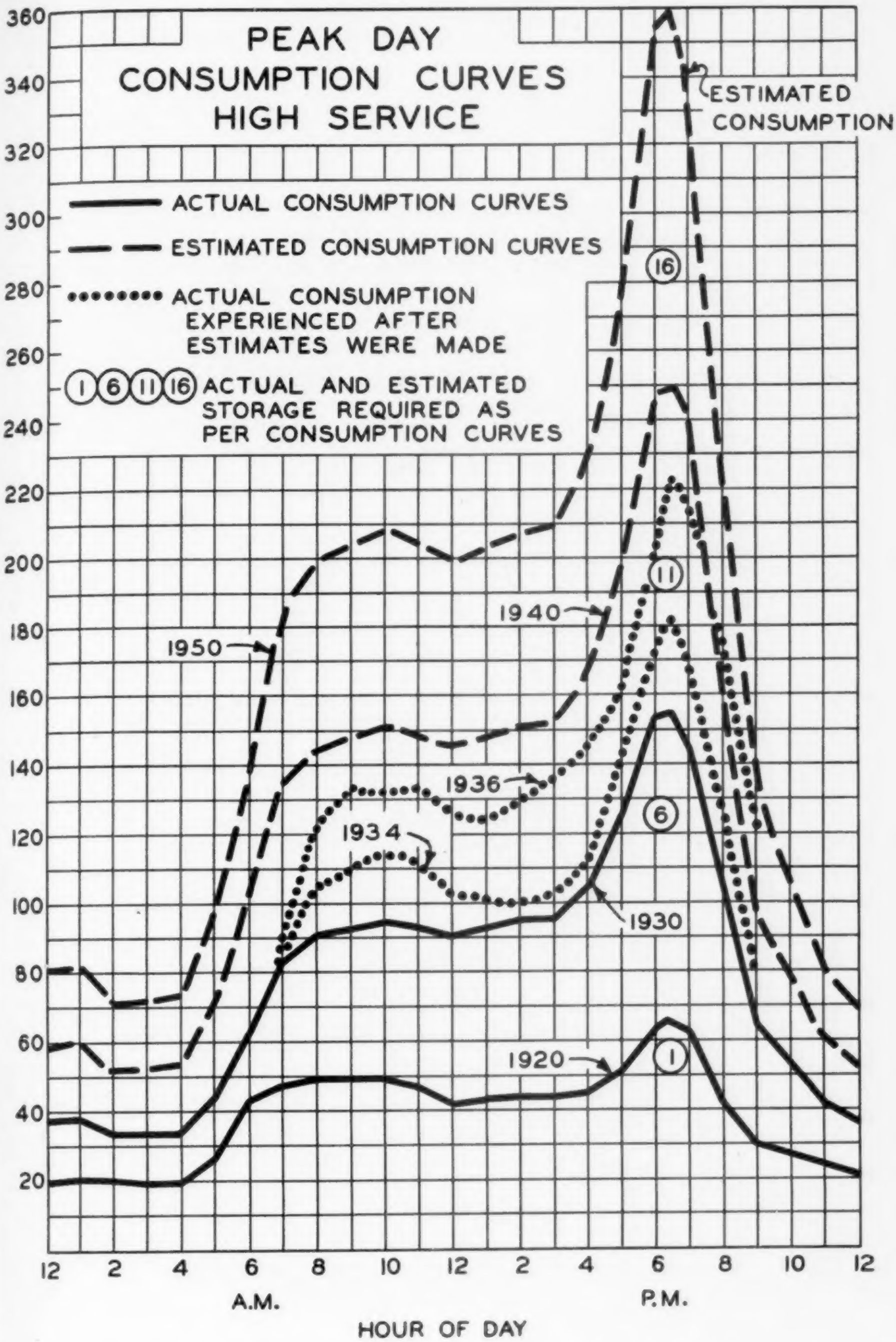


FIG. 20. Peak Day Consumption Curves in High-Service District.

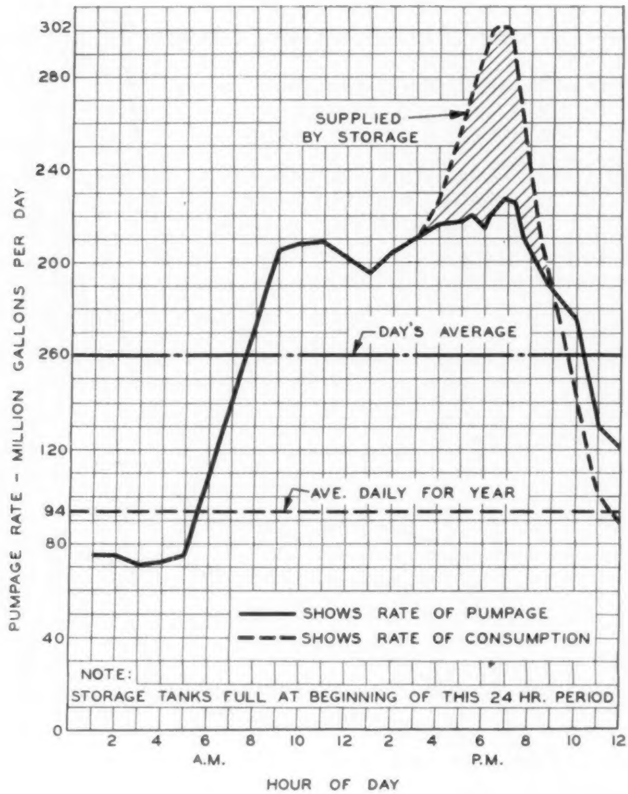


FIG. 21. Pumping and Consumption Rates—Highest on Record.

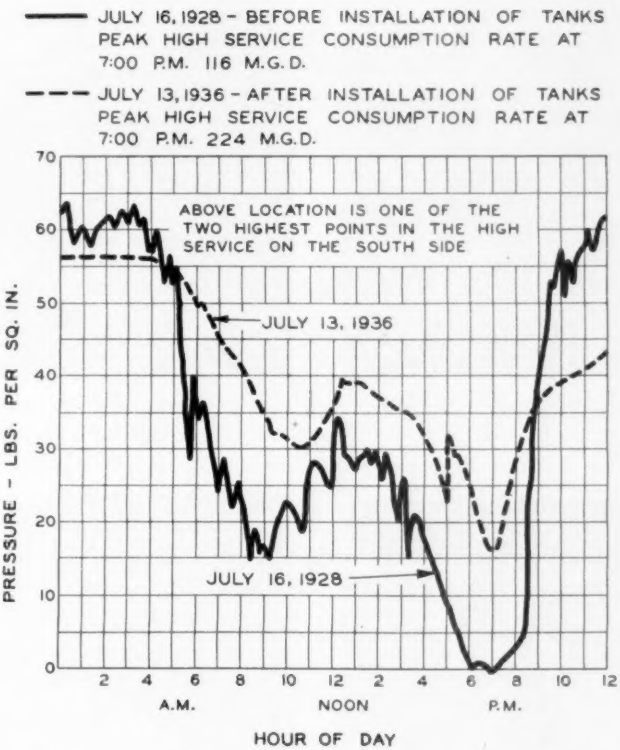


FIG. 22. Hydrant Pressures at High Elevation on South Side in High-Service District Before and After Storage was Installed.

Fig. 23. Typical Pitometer Installation.

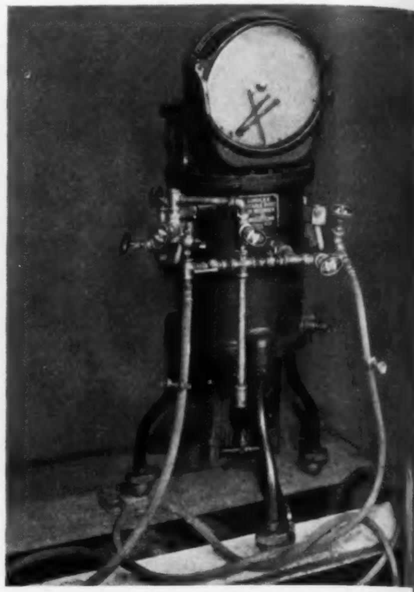


Fig. 24. Pitometer Recorder and Tubing Connected to Main.

Fig. 25. Typical Pressure Gage Installation.

Fig. 26. Pressure Gage.

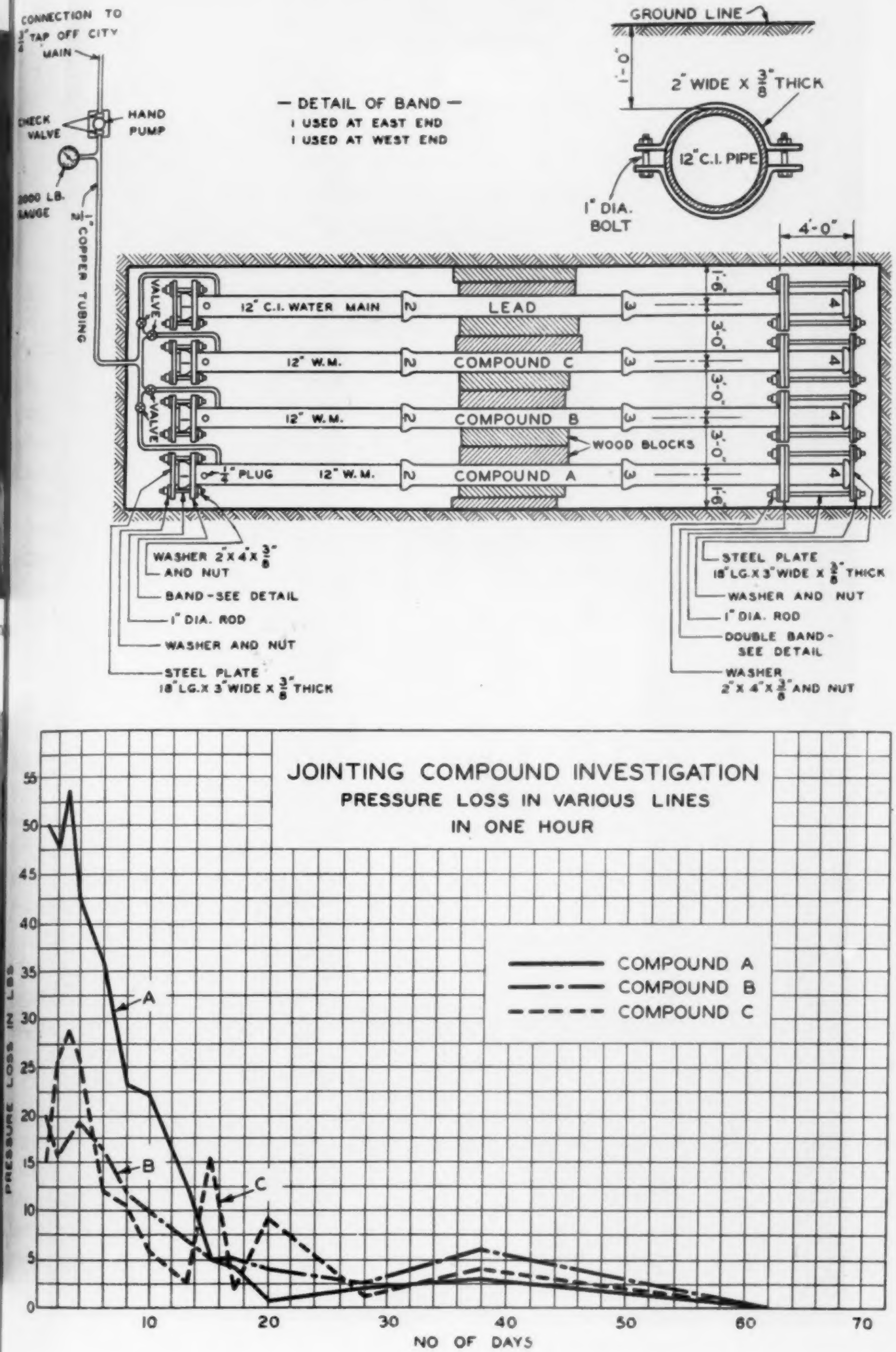


FIG. 27. Tests of Jointing Compounds.
(*Top*) Layout of Mains for Field Tests; (*Bottom*) Pressure Loss in Test Mains.

Milwaukee Water Works Booth at Milwaukee Conference, A.W.W.A., 1944.

Milwaukee Water Works Booth at Milwaukee Conference, A.W.W.A., 1944.

The Operation and Maintenance of the Milwaukee Water Works System

By Herbert H. Brown

THE Milwaukee Water Works is operated as a bureau of the Department of Public Works under a mayor-council form of city government. Being a utility, it is also under the jurisdiction of the Public Service Commission of Wisconsin which approves rates, rules and regulations. The water works was originally constructed and has been in operation since 1874 and now serves a total population of 667,800, of which 602,000 reside in the city proper and 65,800 in the suburbs.

The water department is divided into nine divisions with a total of 450 employees, all of whom are under civil service, work 40 hr. per wk., are members of a general city pension system, and receive sick leave benefits as do the other city employees.

Before discussing management problems, I would like to present a general picture of the various facilities of the department.

Purification Division

Lake Michigan is the source of Milwaukee's entire water supply. A submerged intake is located 1¼ mi. out in the lake in 67 ft. of water. The intake tunnel is 12 ft. in diameter and has a capacity of 220 mgd. at a velocity of 3 fps. and 366 mgd. at 5 fps. A bypass, consisting of a dry well between two sluice gates, has been provided. In the event of a serious interruption of power on both incoming underground lines, the gates can be opened and an unfiltered but chlorinated supply can be furnished.

The raw water taken from Lake Michigan is moderately hard, free from color, of a low but variable turbidity, a very low iron content, and free from manganese. The average coliform index is low, normally being less than 50, but it is subject to a rapid increase during periods of high runoff or wind storms, particularly if the wind happens to be from the south and carries to the intake the effluent from the sewage treatment plant and the discharge from the three rivers entering the harbor.

The water purification plant, constructed at a total cost of $5,511,225, was placed in operation on July 1, 1939 and is the rapid sand or mechanical type. The plant has a rated capacity of 200 mgd. and was built on 24 acres of made land projecting into Lake Michigan and near the shore end of the concrete intake tunnel which brings the raw water to the plant. Four 50-mgd. and one 75-mgd. electrically-driven low-lift pumps operate against a 30-ft. head and provide plant capacity with the largest unit out of

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A paper presented on June 13, 1944, at the Milwaukee Conference, by Herbert H. Brown, Supt., Milwaukee, Wis., Water Works.

service. There are two coagulation basins, each 297 ft. × 372 ft. overall. A vertical wall divides each basin into two sections (148 ft. × 372 ft.) which can be operated independently. The mixing chambers are about 150 ft. x 75 ft. in the forepart of each section and are equipped with flocculators. The settling or sedimentation tanks are about 150 ft. x 300 ft. in size and are of the double deck type. The mixing chamber and sedimentation tank together are called the coagulation basin and this has an inside height of 28 ft. When operating at 200 mgd. the mixing time is 1 hr. and the settling time is 4 hr.

The building contains 32 filter units, each with a sand area of 38 ft. x 57 ft. and a capacity of 6.25 mgd. at the standard 2-gal. filtration rate. Twenty-seven inches of sand and 24 in. of gravel overlie standard cast-iron underdrains. A system of surface wash of the fixed-grid piping type supplements the standard backwash system. A concrete wash-water tank has a capacity of 750,000 gal. and was constructed underground on top of the bluff in the public park west of the plant. Three interconnected filtered water reservoirs have a total capacity of 30 mil.gal. One reservoir is under the filters and the other two reservoirs are underground and separate concrete structures.

The following chemicals are used in the purification process: aluminum sulfate, ammonium sulfate, activated carbon, lime and chlorine. All dry chemicals are stored in overhead steel bins and are fed through modern gravimetric feeders. Three carbon fires have occurred in the storage bunkers and were extinguished with carbon dioxide. Great care must be exercised when handling large quantities of carbon in order to prevent excessive dusting of equipment and fires.

Chemicals, including chlorine, are applied to the raw water in the pipeline between the pumps and the mixing basins. Lime is used only when required for the adjustment of the hydrogen ion concentration, and carbon when required for odor control. Carbon can also be applied at the outlet of the settling basin. Ammonium sulfate and chlorine are continuously applied in the effluent tunnel between the clear well and the gate house.

The average daily chemical doses for the past four years have been as follows:

Aluminum Sulfate...	70 to 95	lb. per mil. gal.
Carbon (when used).	10 to 100	lb. per mil. gal.
Lime (when used)...	10 to 40	lb. per mil. gal.
Ammonium Sulfate, post..............	1.5 to 2.5	lb. per mil. gal
Chlorine, pre.......	3.4 to 5.5	lb. per mil. gal.
post......	1.2 to 1.4	lb. per mil. gal

The complete cost of operation and maintenance, including low-lift pumping and care and upkeep of the grounds, for the year 1943, was $6.52 per mil. gal.

The plant has been in operation for 5 yr. Once the initial adjustments and additions incidental to placing the plant in operation had been completed, very few repairs of major importance were required.

The plant personnel consists of 53 permanent and four part-time employees, including a full-time electrician, machinist, and machinst's helper. There are six shifts. All men work 40 hr. per wk. except the second swing shift which works 32 hr. The shifts are changed every four weeks, and the 32-hr. wk. which the men get for four weeks twice a year compensates them for the loss of holidays. Having six shifts permits one and three-fifths

shifts to be assigned to shop duty when the men are not taking the place of others who may be sick or on vacation. This arrangement makes available trained operators to do maintenance work and has worked out very well.

Pumping Division

The two major pumping stations are steam-driven with all power generated at each station. All maintenance and repair work is performed by water department employees with the aid of a modern and well-equipped machine shop at each station. In 1943 a total of 37,011,890,000 gal. of water was pumped, of which 62.72 per cent was in the high-service district and the balance in the low-service district. The North Point Pumping Station pumped 39 per cent of the total water and the Riverside Pumping Station pumped 61 per cent.

North Point Pumping Station

The North Point Pumping Station is the oldest pumping station of the water works and has been in operation since September 14, 1874. It is located on the shore of Lake Michigan approximately 1¼ mi. south of the water purification plant. The pumping equipment consists of eight pumping engines of the vertical triple-expansion crank and fly-wheel type. The total pumping capacity of the eight pumps is 126 mgd. Four of the pumping engines are low-service pumps operating against an average dynamic head of 148 ft., and four are high-service pumping engines which operate against an average dynamic head of 264 ft. There are two 300-hp. and three 400-hp. horizontal water tube boilers which provide the necessary steam to operate these pumps. Water flows by gravity from the clear wells at the water purification plant to the suction wells at the pumping station. The suction pipe of each pumping engine extends into and within 2 ft. from the bottom of one of the wells. After the water passes through the pumps, it is discharged into one of the five large feeder mains varying from 30 in. to 42 in. in diameter, leaving the pumping station on the west side of the building.

Riverside Pumping Station

The Riverside Pumping Station has been in operation since July 1, 1924, and is located approximately 1⅓ mi. west of the water purification plant. The total pumping capacity of the six pumps is 184 mgd. Five of the pumping engines are high-service pumps which operate against an average dynamic head of 262 ft., and one pumping engine is a low-service pump operating against an average dynamic head of 148 ft. Four of the pumping engines are of the vertical triple-expansion crank and fly-wheel type, and two are turbo-centrifugal units. Water flows by gravity from the clear wells at the water purification plant to the suction tunnel of the pumping station. The discharge from each pump is taken by a 42-in. main. The discharge of two adjacent units join into a 54-in. feeder main in front of the station.

Full radius sweeps and easy curves have been built into the distribution system on the pumping station grounds so as to reduce the friction losses to a minimum. A carefully designed and valved gate house enables the discharge from the pumps to be routed through almost any desired portion of the distribution system. The boiler room at this station contains six 400-hp. horizontal water tube boilers.

Menomonee Valley Booster Station

This station is located on the west edge of the city at a ground elevation of approximately 16 ft. above Lake Michigan, and contains three 30-mgd. electrically-driven centrifugal pumps. Adjacent to the station are two 6-mil. gal. ground-level all-welded steel storage tanks which fill during the night hours under normal pressure. Water is pumped from the storage tanks at increased pressure directly into large feeder mains in the street east of the station.

The station is operated only during the summer months between the hours of 5:00 p.m. and 8:00 p.m., during peak periods of water consumption in the high-service district when lawn sprinkling creates a very heavy demand which is of but short duration. The operation of this station materially reduces the large pressure drop which heretofore existed between the pumping stations and the outlying districts of the city during periods of high consumption, and provides a higher and more nearly uniform pressure to these districts.

Future development at this station provides for an additional pumping unit of 30-mgd. capacity.

Distribution Division

The distribution system consists of 1008.28 mi. of cast-iron pipe ranging in size from 4 in. to 54 in. The 4-in. mains were acquired in 1929 through the annexation of the former city of North Milwaukee. New mains are laid under contracts awarded by the Commissioner of Public Works, and their installation is supervised by the Construction Division of the water works. Department employees perform all maintenance and repair work and make minor changes to the system.

There are 19,300 distribution valves and 8,621 hydrants in the system. All services are owned and installed by the consumer in accordance with rules set up by the water department, but are maintained by the department to the curb stop on the domestic taps and to the curb line on the branch connections. Copper tubing or extra strong lead pipe is permitted for the $\frac{3}{4}$-in., 1-in., and $1\frac{1}{4}$-in. services; copper tubing or double extra strong lead pipe for the $1\frac{1}{2}$-in. and 2-in. sizes; and bell and spigot class "C" cast-iron pipe for the 3-in. and larger sizes. A total of 139,243 service connections has been made with the distribution mains. The number of services in actual use is 99,612, of which 98.78 per cent are metered.

Two storage or pipe yards are maintained and a complete stock of water pipe, fittings, valves, and hydrants is kept for new construction and maintenance of the distribution system. Incoming material is unloaded by department employees and hauled to construction projects by the Bureau of Municipal Equipment.

A recent pitometer survey showed the trunk main system to be in excellent condition. This report, along with the fact that wartime requirements in this industrial area was imposed no difficulties nor caused any complaints as to the adequacy of the service, proves how well the system was designed and is being maintained.

A 25-mil.gal. storage and equalizing reservoir has been in service on the low-service system since 1874. Storage on the high-service district is provided by two elevated storage tanks of $1\frac{1}{2}$-mil.gal. capacity each, and two 6-mil.gal. ground-level steel tanks previously mentioned at the Menomonee Valley Booster Station. The elevated tanks are drained and taken out of

service during the winter months, since their function is to bolster pressure in the particular area in which they are located during periods of peak consumption in the summer time. One tank floats on the distribution system at all times during the summer months and the other tank, by means of a time switch, pressure switch and control valve, discharges between the hours of 5:00 p.m. and 8:00 p.m. and then is refilled during the night. Both tanks serve their purpose exceedingly well, at a nominal cost, and without the daily services of an attendant.

Division of Meters and Services

This group of 29 employees is responsible for the office, shop and field activities and records of the installation and maintenance of all water meters; supervisory control of unmetered fire-protection systems; inspections of cross-connections; investigation of complaints of services and contested meter bills; and furnishing hose service to large consumers temporarily out of water.

Meters in Milwaukee are furnished by consumers but are maintained free-of-charge by the water department, except when damaged by frost, hot water or water hammer. New meters are sent to the meter shop for testing, after which they are installed by water department employees. There are 98,393 meters in service which account for 92.54 per cent of the total revenue received by the department.

Private fire-protection services are unmetered, but a new rule is contemplated which will require the installation of meters on such lines where the underground piping extends more than 100 ft. beyond the lot line; where the underground pipe on a yard system exceeds 100 ft.; or where hydrants or other attachments are made to the branch connection. The intention is to pick up and bill a customer for the water lost through leakage or through any illegal connections. No charge would be made for water used for extinguishing fires.

Collection Division

This division reads all meters and assesses and collects all established rates. Bills are rendered quarterly and the city is divided into three districts, so that there is a collection period each month. Bills are delivered by the meter readers on the first day of the month and are payable by the twentieth day of the same month. No discount is allowed, but a penalty of 5 per cent is assessed if the bill is not paid when due. Water bills are a lien against the property, so no record is kept of the names of owners or tenants.

Large consumption meters are read biweekly by three senior meter readers. The other meters are read monthly by the 46 meter readers in order to discover any high consumption or defective meters. Since the department cannot allow refunds for high consumption due to leaks or breaks on the premises, the department considers it important in its relations with the public to read meters monthly.

Of the total pumpage for the year 1943, 83.07 per cent was metered, 1.23 per cent was estimated as flat-rate consumption, 2.49 per cent was estimated for under-registration of meters, and the balance of 13.21 per cent was estimated for non-revenue water which includes flushing and filling of mains, settling trenches, leakage, breaks in mains, and "unaccounted-for" water.

Water rates in Milwaukee consist of two parts: first, a sliding scale for water ranging from $6\frac{3}{4}$ cents to $5\frac{1}{2}$

cents per 100 cu.ft., depending upon the quantity used per quarter; and second, a service charge ranging from 75 cents per quarter for a $\frac{5}{8}$-in. or $\frac{3}{4}$-in. meter to \$844 per quarter for a 24-in. meter. A surcharge of 25 per cent on the total bill is applied on bills to consumers outside the city limits. A sliding-scale rate to suburbs, called "Suburban Resale and County Service," varies from $9\frac{1}{2}$ cents to $7\frac{1}{2}$ cents per 100 cu. ft. per quarter for water, plus a service charge similar to the rate for urban users.

Parks Division

The grounds around the water purification plant, both pumping stations, the booster station, and around the low-service reservoir (known as Kilbourn Park) are maintained under the supervision of the foreman of parks. This area of approximately 100 acres is maintained with a maximum of 35 park laborers, the actual number varying with the season of the year. The maintenance of grounds includes care of trees, shrubs, flowers, park buildings, walks, underground sprinkling systems and various playground facilities.

Six band concerts are held in Kilbourn Park at the expense of the department, and bids are taken each year for the concession to sell ice cream and soft drinks in Kilbourn Park and on the grounds of the North Point Pumping Station.

Accounting Division

This division of twelve employees in the general office handles all accounting work for the entire department. This work includes accumulating all costs of operation; preparing payrolls, the annual report, and the annual budget; submitting all financial and operating reports to the Public Service Commission; billing unmetered accounts; issuing permits for the use of unmetered water and for the installation of services by plumbers. Requisitions for supplies and materials are routed through this office to the Central Board of Purchases of the city.

A utility plant property record was installed in 1938 under the supervision of the Public Service Commission of Wisconsin to comply with the requirements of the uniform system of accounts for water utilities. This record shows by years, for each class of property, the number and cost of plant units added, retired, and still in service.

The following financial statistics are taken from the 1943 annual report of the department:

Total cost of water works	\$34,991,983.16
Depreciation written off	6,357,671.90
Contributions in aid of construction	6,533,728.28
Bonded indebtedness	2,007,000.00
Total operating revenues	3,394,185.14
Total cost of utility operation, including taxes and depreciation	2,539,973.11
Net income	785,441.38
Surplus earnings transferred to General City Fund	1,000,000.00
Surplus earnings transferred to General City Fund to date	16,837,965.00

General Administration

Some problems other than those of a routine nature or those brought about because of the war require consideration.

Over a long period of years the Milwaukee Water Works has been involved intermittently in rate litigation before the Public Service Commission and in the courts, because certain consumers believed that the utility was enjoying too high a rate of return or because, as a class of consumers, they believed that their rates should be re-

duced. All legal matters are handled by the city attorney, but a great deal of assistance must be given to the attorney in the preparation of cases, hearings, exhibits, etc., at a sacrifice of time normally devoted to the administration of the utility.

Because consumers own and install meters, there are now attached to the system 31 different makes and models of meters ranging in size from $\frac{5}{8}$ in. to 16 in. Since the department repairs the meters, a very large inventory of parts must be kept in stock and each meter must be segregated and carefully handled in order that it may be returned to its rightful owner.

The department is handicapped in its administration by a set of "Rules and Regulations" dating back to 1921. Repeated attempts have been made to have the Common Council bring these rules and regulations up to date, but always some item is brought forward which brings about the convenient and proverbial "postponement" of action.

The water department, like all other Milwaukee city departments, is saddled with a double scale of wages for every position. There is nothing that lowers the morale and causes more dissatisfaction to an employee than when he realizes that he receives lower wages than the man working next to him who is performing identical duties. This condition was brought about as a belated depression measure when the Common Council in 1940 saw fit to establish a lower scale for new employees. This situation may be corrected next year due to a comprehensive study that is now being made by a committee representing the five taxing units of government within the city to establish "like pay for like work."

Management of financial matters sometimes becomes involved because financial policies are established by elected officials of a Common Council to apply to all city departments, with no special consideration of the water department functioning as a public utility. An annual budget is approved by the Common Council, and whether it may be higher or must be lower than the budget of the previous year is influenced by the policy adopted for all city departments.

Development of Centrifugal Pump Discharge Valve Control at Milwaukee's Riverside Pumping Station

By Harrison B. Hoefer

PLANS and specifications for centrifugal pump installations do not always give sufficient consideration to the prevention of centrifugal pump reverse rotation, particularly in those instances where two or more pumps are connected in parallel to a discharge header or main. There are, of course, numerous other operating conditions which deserve consideration, but time and space do not permit their discussion.

Before going into the design and operation of the discharge valve control developed at Milwaukee's Riverside Pumping Station, it is well to consider the reasons and conclusions which prompted its development. Centrifugal pump reversals can result, and have resulted, in the destruction of pumping units, the necessity for costly repairs, prolonged idleness of units, and the interruption, in whole or part of the flow of water to consumers. The serious and far-reaching consequences incident to such occurrences surely warrant every effort to provide complete protection against pump reversals. Such protection is assured by installing a check valve in a centrifugal pump discharge line. It is also desirable, and hydraulically correct, to provide hydraulic control of the pump, or in other words, to control the rate of pump discharge when the pump is being started or stopped. This can be accomplished through the installation of an automatically-controlled discharge valve on the pump discharge.

There will undoubtedly be some who will disagree with the above dual valve arrangement. They may contend that pump reversals occur infrequently, that one or the other of the valves is unnecessary, that dual valves add only to the cost of the installation, that check valves cause surges which produce damaging water hammer and that their resistance to flow affects pumping economy. An analysis of these objections reveals, however, that they are of secondary importance when compared to the advantages of the dual valve arrangement.

The infrequent occurrence of pump reversals does not necessarily imply that adequate protection against such a contingency has been provided. It means rather that frequent pump reversals have been prevented, because the operating personnel, when at its post during the normal function of starting and stopping pumping units, is alert and prepared to meet any emergency which may arise. However, where a centrifugal pump does not have check-valve protection and where the prevention of reverse flow depends

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entirely on the functioning of an automatically-controlled discharge valve, it is evident that, should this discharge valve fail to close during a pump stoppage, pump reversal will result. It is this uncertainty of proper valve operation which is most feared by the operating personnel, for under such conditions the prevailing excitement and confusion are bound to retard the prompt action which is necessary to prevent pump reversal.

Considering the purpose and function of the two types of valves, namely, the check valve and the automatically-controlled discharge valve, we find that the check valve is strictly a non-return valve with the sole function of preventing reverse flow. It is consequently the ideal valve to prevent centrifugal pump reversal. Despite the objections to its use, it is, nevertheless, the only true non-return valve. To justify its use and also that of the dual valve arrangement, it may be timely to consider the two primary objectives and duties of those who operate a water works. There will be little argument if these be stated as: (1) to furnish a healthful and uninterrupted flow of water to all consumers, and (2) to furnish such service as economically as possible.

If these objectives are reasonable, then it is also reasonable to suggest that valves which fulfill the requirements for such service be utilized. The objection to check valves as being responsible for damaging surges and water hammer is applicable only to the flap or hinge type. And the further objection of resistance to flow-reducing pumping economy deserves only secondary consideration, because safety of operation should take precedence over the ultimate in economy of operation. It is also true that in the better types of check valves, resistance has been reduced to a minimum.

The automatically-controlled pump discharge valve performs a highly desirable function without which centrifugal pump control is not complete. Its primary function is to provide hydraulic control of the pump. In other words, it controls the rate of pump discharge when starting and stopping, thereby eliminating sudden changes in water pressure. It also controls the timing or rate of opening of the check valve when used in combination, thereby minimizing the objection to the use of a check valve in the discharge line. In stressing the importance and desirability of automatically-controlled discharge valves, we should not lose sight of the fact that they are highly mechanical in design, and like all mechanical devices, can get out of order and fail to function. It is the opinion of the author, therefore, that the entire dependence for protection against centrifugal pump reversal should not be placed on automatically-controlled pump discharge valves.

Relative to the contention that the dual valve arrangement is unnecessary and extravagant, it may be well to consider a particular case of pump reversal with which the author is familiar. It happened in the summer time during the peak pumping season and resulted in a pump of high capacity being out of service for 30 days. The total pumping capacity of the system was so reduced that had another pumping unit become disabled it would have been necessary to order restrictions in the use of water. A condition such as this was in mind when the term "far-reaching consequences" was used earlier in this paper. The above was not the entire consequences for in addition a total expenditure of approximately

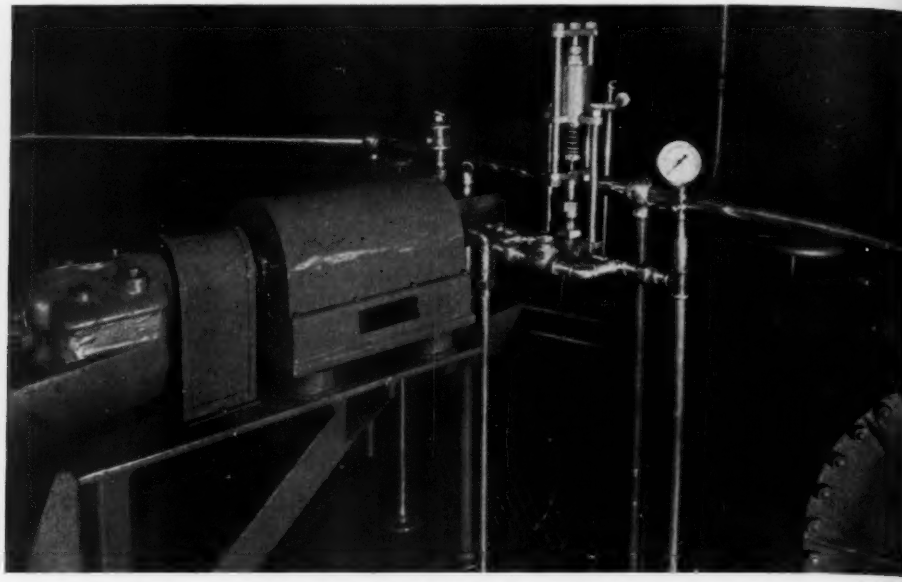


Fig. 1. Control Attached to Shaft End of Centrifugal Pump, as It Looks With the Safety Guards in Place and in Operating Condition

$2,800 was required to re-establish the damaged unit. Comparing this figure with the approximate cost of $3,800 for a check valve, it would seem that the latter would have been a sound investment, for a check valve in the discharge line would have prevented the reversal and would have provided further protection against such an occurrence for all time. It should be stated also that, had not the pump reversal been checked as promptly as it was, the damage to the unit would have been much greater.

From the preceding discussion, it should be evident that the suggestion of a dual valve arrangement is not made without deliberation and cause, and that the combination of valves is not as unnecessary and extravagant as it may appear on first appraisal. Those of us who are intrusted with the safe operation of the centrifugal pumping units in the Milwaukee Water Works firmly believe that pump reversals should be made an impossibility. The pump discharge lines at the Riverside Pumping Station were planned and designed to serve reciprocating pumping engines and as a result the piping arrangement does not afford the desired protection against centrifugal pump reversal under all pumping conditions. Furthermore, the controls on the automatically-controlled pump discharge valves at the station have not proven entirely reliable. Consequently, to be consistent with the opinion expressed heretofore, it is natural that we would attempt to make the existing automatically-controlled discharge valve approach the effectiveness and dependability of a check valve. After considerable study and experimentation with a pump discharge valve, it was concluded that its control or pilot

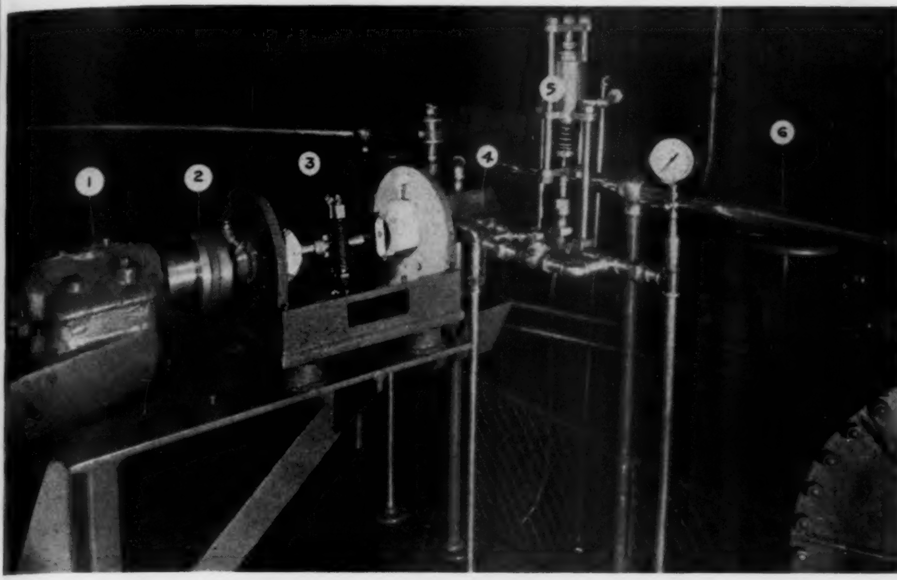


FIG. 2. Control Attached to Shaft End of Centrifugal Pump, With Safety Guards Removed. Numerals identify principle parts of control. They are: (1) Centrifugal pump outer bearing that supports pump shaft to which control is attached; (2) One-way rotary clutch which prevents control from operating to discharge valve opening position should pump tend to reverse; (3) Governor which actuates valve of the four-way pilot valve; (4) Four-way pilot valve assembly; (5) Pressure-controlled water supply valve from four-way pilot valve; (6) Original four-way water supply valve for the pump discharge valve hydraulic cylinder. Newly-developed control operates four-way water supply valve.

valve could be improved by tying its operation in with the rotation of the pump. After a discussion of this subject with H. H. Brown, Superintendent of Water Works, a decision was reached to make and install a new control on the No. 5 steam-turbine-driven pump at the Riverside Pumping Station. However, prior to its installation, the control was placed on a test block and operated continuously day and night for six weeks to determine the quality of the materials used and the sharpness of its action. The test proved its possibility, and since its installation on No. 5 pump, the control has been operating continuously and performing its intended function very satisfactorily.

Discharge Valve Control

The operation of the discharge valve control, as stated previously, is based on pump rotation, meaning that when the pump is not rotating, the discharge valve control and the discharge valve will remain in their respective closed positions.

Related and Principal Parts of Control

The related and principal parts of the control are:

1. Pump bearing and shaft.
2. One-way rotating clutch coupling.
3. Weight spring loaded centrifugal governor.
4. Four-way pilot valve.

5. Pressure-operated water supply valve.
6. Controlled water supply valve for the discharge-valve-operating hydraulic cylinder.

Function of Parts

The several parts function in the following manner:

(2) *One-way rotating clutch coupling.* The clutch coupling is the drive for the control. It is keyed to a driving stud which is attached to and driven by the pump shaft and is designed so that it will drive the control only when the pump is rotating in the pumping direction. Therefore, the control, and likewise the controlled discharge valve, can only operate or move to their respective open positions when the pump is rotating in the pumping direction at or above a predetermined opening speed.

(3) *Weight spring loaded centrifugal governor.* The governor actuates the valve of the four-way pilot valve to which it is attached in the following manner: It is installed in a horizontal position and has its maximum over-all length when not rotating. When the pump is started and has attained the predetermined opening speed, centrifugal force shortens the length of the governor and in so doing moves the pilot valve and likewise the discharge valve to their respective open positions. The pilot valve and the discharge valve remain open at any speed in excess of the opening speed. In stopping the pump, when the speed of rotation falls below the predetermined opening speed, the governor recovers its maximum overall horizontal length, and in so doing moves the pilot valve and the discharge valve to their respective closed positions, and they remain closed until the pump is again started.

(4) *Four-way pilot valve.* The four-way pilot valve is attached to and actuated by the governor. Its function is to supply water to the actuating piston of the four-way valve which supplies water to the hydraulic piston which operates the automatically-controlled pump discharge valve.

(5) *Pressure-operated water supply valve.* This valve functions to prevent the discharge valve from opening in the event of the pump's failure to pick its suction or of its not being primed, even though the pump is rotating at the pump discharge opening speed. The pressure-controlled valve is opened by pressure and closed by spring tension. If the pump is not primed or fails to pick its suction, the pressure required to open it will not develop and the pressure-controlled valve will not open. Consequently, there will be no flow from the controlling pilot valve to the pump discharge valve and the latter valve will also remain in the closed position. However, if the pump is primed, pressure will be developed, the pressure-controlled valve will open and the resulting flow to the discharge valve will open that valve also, and they will remain in their respective open positions until the speed of the pump has been reduced to the predetermined opening speed.

This new control replaces the original pilot valve and diaphragm control assembly of the automatically-controlled discharge valve and provides the following desirable operating features:

(a) Positiveness of operation because it is connected to and operated by the pump shaft.

(b) The control and likewise the discharge valve cannot move to their

respective open positions until the pump has attained the desired speed or rate of pumpage.

(c) The control can only function to open the discharge valve when the pump is rotating in the pumping direction.

(d) The control can be adjusted to open and close the pump discharge valve at any desired pump speed or rate of pumpage.

(e) Neither the control nor the discharge valve is dependent on velocity head or differential pressure for closure.

It is believed, therefore, that this control has contributed towards the prevention of centrifugal pump reversal and has also improved the hydraulic control of the pump. This new control does not, however, change the author's opinion that the ideal combination consists of a check valve to prevent centrifugal pump reversal and an automatically-controlled discharge valve to provide hydraulic control of the pump.

Summary and Conclusions

1. The far-reaching consequences resulting from centrifugal pump reversals should lead to steps to make such incidents impossible.

2. The combination of a check valve and an automatically-controlled discharge valve is ideal to prevent centrifugal pump reversal and provide hydraulic control of the pump.

3. Where new centrifugal pump installations are contemplated, serious consideration should be given to the dual valve arrangement.

4. The dependability of pump operation and hydraulic control of the centrifugal pump discharge valve is greatly improved when the control is attached to the pump shaft and operated on the principle of pump rotation.

5. In existing installations where entire responsibility for prevention of reverse rotation is placed on an automatically-controlled discharge valve, and where existing conditions prevent the addition of a check valve, an effort should be made to make the automatically-controlled discharge valve approach the effectiveness of a check valve.

The Milwaukee Water Works has attempted to meet this latter condition by the development of the new centrifugal pump discharge-valve control. Plans are now being prepared to provide, as a postwar project, complete check valve protection for the centrifugal pumps at Riverside Pumping Station.

Modernizing Meter Rates

By Charles H. Capen

UNQUESTIONABLY, meter rates are hemmed in with almost insurmountable barriers of custom, expediency and inertia. Every water works man knows that even a slight change in established rates is quite apt to bring a storm of protest from the local clubs, public press, sewing circles, J.Q.P. (John Q. Public) and, in fact, almost anyone who can read, write or talk about affairs concerning which, most frequently, his lack of knowledge is amazing.

Almost any water engineer or superintendent who could be free to speak his mind would welcome an opportunity to turn his rate schedule inside out, scrub off the barnacles, even out the inequities and make the public take it and like it. No one can deny that such a procedure would set most water systems on a real, honest-to-goodness, paying and reasonable basis. Even the sugar coatings in the form of large rebates, trick minimum charges and free water to institutions might be dissolved in the housecleaning. But will this Utopia ever be reached? Figure it out for yourself!

Typical Rate Problems

At the 1943 annual conference of the Wisconsin Section of the American Water Works Association, a very comprehensive paper was presented by Schwada and Tanghe (1) in which particular stress was laid on the questions of the rates to large users, and the rates to suburbs, considering particularly the distance from the source of supply. Further comments controverting any ready basis for a comparison of rates were ably presented by Weir, Hoffman and McCord (2). Since the writer takes issue with some of the viewpoints expressed in those papers, this opportunity is taken to set forth the opposing arguments.

The contribution by Schwada and Tanghe (1), regarding rates in Milwaukee, represents a most detailed analysis of costs and was amply justified because the suburb involved in that particular rate case claimed lower rates on the basis of proximity to the pumping station. This claim was at variance with accepted American practice for utility rates.

In northeastern New Jersey one large public utility serves hundreds of separate municipalities with gas, electricity and transportation. Rates for the first two are equal throughout the area regardless of location. Transportation, however, is divided into zones and zoning is likewise used for telephone service which is also controlled by one large company. Probably gas and electric service can be most closely compared with water service and here we find uniform rates. The same is

A paper presented on June 16, 1944, at the Milwaukee Conference by Charles H. Capen, Civil and San. Engr., West Orange, N.J.

generally true of similar situations throughout the United States.

The city of Milwaukee presented an excellent analysis of costs, and the conclusions were supported by the Circuit Court, although not entirely by the Public Service Commission. It should be particularly noted that all three parties appeared to have considerable doubt as to the wisdom of trying to apportion costs accurately on the basis of distance from the source of supply. In this connection it may be said that without regard to equity, the existence of uniform rates is an American institution which cannot be lightly disregarded. No one can deny that there is much merit to the claim that an outside municipality should "not expect service at the same prices charged residents of the city." Quite often rates to such outside municipalities are higher than to consumers within the city limits, but usually such outside rates are in themselves uniform without regard to which of the satellite municipalities is nearest to the source of supply.

The Milwaukee case illustrates the apparent futility of attempting to justify a rate to an outside consumer purely on a basis of cost. Rather, it appears to the writer that the cost should be comparable to similar uses within the city limits, with perhaps an added increment or percentage for reason of inability of the City to gain any further recompense in the form of taxes or assessments. There is no attempt made here to justify this viewpoint other than to say that it conforms to general American practice and that it is certainly just as logical as most water rates. It is equally illogical to go through a rate case as Milwaukee did and arrive at a conclusion that is entirely unsatisfactory to all concerned after a period of ten years of litigation.

In the paper and discussions by Weir, Hoffman and McCord (2), the viewpoint is taken that each system is a law unto itself and that comparisons with others are both futile and unfair. The writer disagrees with that conclusion and presents herein some reasons to amplify this belief.

Results From Existing Records

Much may be gained by careful study of the practices and experiences of others. It was with this in mind that the A.W.W.A. published, in 1923, a committee report on a standard form of rate schedule (3). Capen (4) has previously pointed out some of the shortcomings of such a system. The fundamental idea of establishing a typical rate schedule cannot be questioned. It is believed that a number of factors must be taken into consideration other than those primarily governing the committee recommendations. Moreover, the increasing practice of adding sewer rentals to water bills is becoming sufficiently common to warrant recasting the entire schedule, wherever such charges are in vogue.

It is not the function of this paper, however, to expand at length on the subject of combined water and sewer rates. Rather a comparison of existing water rates and some comments thereon seems to be far safer and surer ground on which to tread.

A significant contribution to the subject was made by the late Leonard Metcalf (5) in his study of water rates in relation to growth in population and per capita consumption (the figures having been collected in the early twenties). Capen (6 and 7) has also reported on this, the data being taken

from figures on operation in 1932, 1936 and 1940.

Within the last two years, figures were gathered from 30 large and 280 smaller cities, by Barcus, Kindred and Co. of Chicago (8). These are quite well arranged and deserve comparison with other records. Recent publication of records tabulated by the American Water Works and Electric Co. (9) adds still further information of value. Table I shows a grouping by which these several records may be compared.

This table permits plotting of a curv on logarithmic paper and determina tion of the equation thereof. By simila methods, Capen (4) had previousl shown that the equation was approxi mately

$$\text{Meter Rate (M. R.)} = \frac{50}{P^{0.2}}$$

[Equation A

where M. R. represents the meter rat in cents per 1,000 gal. and P is th population in thousands. This equa

TABLE I

Comparison of Average Rates for Water with Gradings According to Population

Population Range *Thousands*	Metcalf 1926			Capen 1932, 1936, 1940		
	No. of Cities	Av. Pop. *Thousands*	Meter Rate Cents Per 1,000 Gal.	No. of Cities	Av. Pop. *Thousands*	Meter Rate Cents Per 1,000 Gal.
1 to 2				24	1.5	49
2 to 5				27	3.5	41
5 to 10	3	7.8	38	24	7.5	39
10 to 25	6	17	28	16	17.5	36
25 to 100	13	49	22	27	50	25
100 to 250	12	148	19	14	150	20
250 to 1,000	13	420	17	21	470	16
Over 1,000	3	1,249	13	5	3,034	11
	50			158		

Population Range *Thousands*	American W. W. & Electric Co. 1939			Barcus & Kindred 1940		
	No. of Cities	Av. Pop. *Thousands*	Meter Rate Cents Per 1,000 Gal.	No. of Cities	Av. Pop. *Thousands*	Meter Rate Cents Per 1,000 Gal.
1 to 2	1	1.5	78			
2 to 5	3	4	57			
5 to 10	10	7.5	52	140	7.5	31
10 to 25	17	16.4	35	101	15	29
25 to 100	21*	44	32	35	35	28
100 to 250	5	126	24	9	140	25
250 to 1,000	1	293	23	25	500	20†
Over 1,000				6	2,800	13.7
	58			316		

* One omitted.

† Omitting sewer service. With sewer service, figure would be 21¢.

tion indicated clearly the inverse relationship between meter rate and population.

From the data given in Table I, Figure 1 has been prepared. The average equation, as established here has been found to be

$$\text{M. R.} = \frac{60}{\text{P}^{0.2}} \quad \text{[Equation B]}$$

which is not radically different from the original relationship shown in Equation A. The increase in the constant in the right side of Equation B as compared to Equation A may be largely ascribed to use of figures from private companies, which necessarily have higher rates, mainly because of taxes. Equation B, however, represents a better general average. The four curves plotted from Table I are in sufficiently parallel agreement to render some credence to the belief that meter rates the country over tend to follow the same general pattern. This is particularly noteworthy when due consideration is given to the large spread in time over which these four independent series of rates have been determined.

The lower bracket of rates may reasonably be expected to fall near the line of the equation

$$\text{M. R.} = \frac{43}{\text{P}^{0.17}} \quad \text{[Equation C]}$$

Likewise the upper bracket of rates, particularly those of private companies, may be expected to be more nearly represented by the expression

$$\text{M. R.} = \frac{81}{\text{P}^{0.225}} \quad \text{[Equation D]}$$

This does not mean that individual instances will not be found outside these limits but it does mean that most rates should occur within the range of Equations C and D and that the most probable average will be Equation B.

Schedules of Rates

The set of meter schedules recommended by the Committee of the A.W. W.A. in 1923 (3) included steps as follows:

3-rate schedule

1st 25,000 gal. per month
Next 225,000 gal. per month
All over 250,000 gal. per month

4-rate schedule

1st 25,000 gal. per month
Next 225,000 gal. per month
Next 2,250,000 gal. per month
All over 2,500,000 gal. per month

A service charge varying with the size of the meter was recommended as an integral part of each rate schedule. It was also proposed that for the three-rate schedule the maximum ratio or spread of rates (i.e., domestic to industrial rate ratio) should be 2 to 1 and for the four-rate schedule the maximum should be 3 to 1. Further recommendations in establishing rates were as follows: (1) consideration of amount of revenue to be raised; (2) amount of spread; (3) proportion of total revenue to be raised from service charges.

There is much to be said in favor of a service charge and most water works men advocate such a charge, but politicians and the public do not generally like the system. The custom of a minimum charge, as frequently employed in gas and electric rates, is far better known and far more popular. After many contacts with this problem, the writer has come to the conclusion that if a change in rates is contemplated, a minimum charge is better for the aver-

age rate of usage, largely because of consumer relations.

This is said with due deference to the many and preponderant viewpoints to the contrary held by many water works men who have wrestled with the problem. One of the most potent arguments in favor of the minimum charge is the fact that human nature is opposed to the idea of paying for a mere connection, regardless of usage. The fact that one gets some water, as in a minimum charge, overcomes most of the objection. Furthermore, the prevailing belief that a minimum charge does not permit as accurate an estimate of revenue as a service charge, can hardly be substantiated.

It is of further interest to investigate the prevailing ratios of domestic to industrial rates as compared to that recommended by the 1923 committee wherein ratios of 2 to 1 and 3 to 1 were recommended. Two decades later we find that the average ratio of the 30 largest cities in the United States is 1.76 to 1, as derived from Barcus and Kindred's studies.

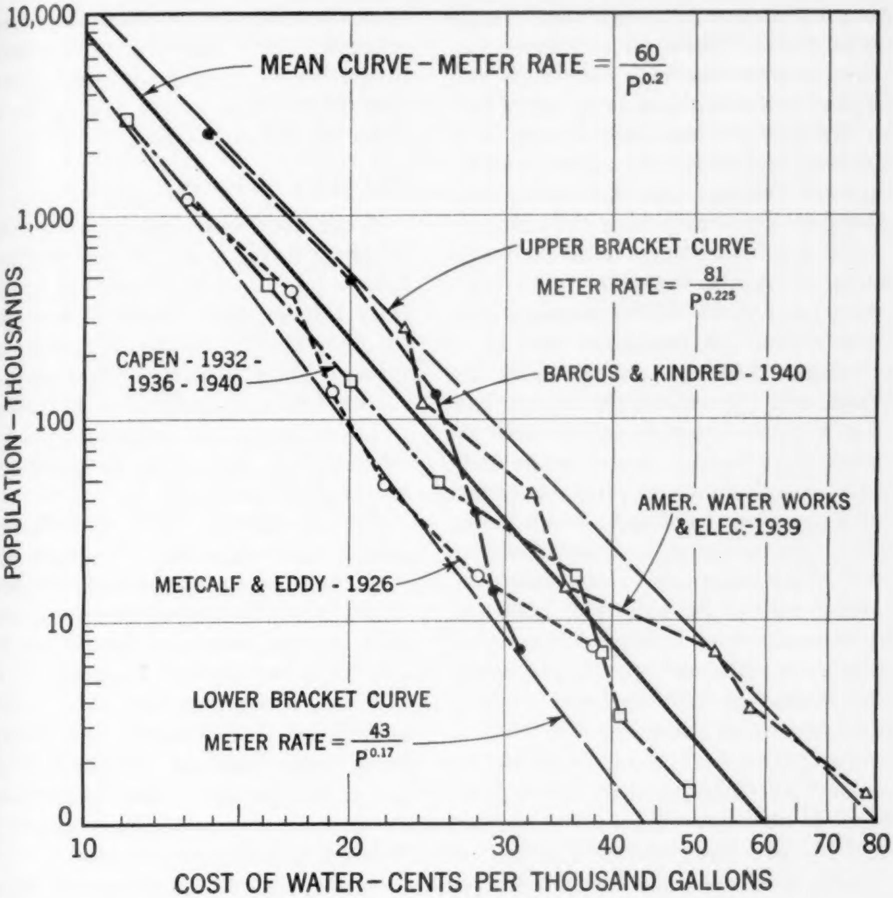
A further examination shows that New York, the largest city, has a constant rate for all quantities and incidentally has the highest large-quantity rate of any of the 30 cities. Chicago, next largest, also has a constant rate, but it is roughly one-third of New York's rate. It must be emphasized, however, that both of these cities are very largely unmetered, even though this condition applies primarily to domestic users. The only other city having a constant rate is Jersey City, which has a rate nearly a mean between those of New York and Chicago—but in Jersey City the system is completely metered.

Of the remaining 27 cities the range of ratios extends from 1.19 to 1 up to 6.5 to 1. Eleven of them have ratios between 1.67 to 1 to 2.5 to 1. This is for large cities, which might be expected to be most apt to utilize the 4-block scale and likewise the 3 to 1 ratio recommended in 1923. It is therefore evident that most systems have not followed the committee recommendations.

In further confirmation of the above ratios, it is found that the average price of water to the domestic user residing in these 30 cities is slightly under 20 cents per 1,000 gal., while the average price to the largest consumers is about 10 cents per 1,000 gal. This again emphasizes the 2 to 1 ratio rather than the 3 to 1 spread that might be expected if the 1923 report were followed.

It becomes pertinent to inquire into justification for such high ratios as 3 to 1. Capen (7) has studied the cost of water delivered at the city-line from most of the same large supplies covered by Barcus and Kindred (8) and has shown that such wholesale water costs somewhat more than 50 per cent of the total cost. On this basis, it might appear that a meter rate ratio of less than 2 to 1 would be in order, rather than the 3 to 1 ratio that would be expected for large cities. On the other hand, it may be noted that the wholesale cost of water is reasonably constant, regardless of the size of the city. It might follow that a higher ratio could be used for small cities than for large ones. Actually the reverse is usually true, mainly because it is the large cities that desire to attract big industrial establishments that would be interested in low water rates.

It may be shown that the operating charges only on the wholesale end of a supply (i.e., at end of transmission line) average about $20 per mil.gal. throughout the United States. Figures



for New Jersey are generally a little lower than this. At the same time, total operating charges in New Jersey reach a figure of between \$50 and \$75. Thus the retail cost could easily be about three times the wholesale figure. If operating charges only were considered, the large consumer rate would be expected to be about one-third of the domestic rate.

Further studies indicate that operating charges are apt to remain reasonably constant, per million gallons, once a system has been well established, but that fixed charges vary widely as improvements become necessary or bonds are retired. It is evident that only by careful long-range planning of expansion can a rate be established that will truly permit a well-balanced rate which can be expected to remain fairly constant. This will require either accumulation of a surplus or payment of annual construction costs out of surplus revenue, in order to avoid large debt service expenditures.

Generally speaking, it is poor business to sell water at less than cost. It becomes necessary, therefore, for any city desiring to attract industries, to determine whether it wishes to subsidize industry at the expense of the do-

mestic consumer, if a high ratio of steps is proposed. There are, of course, isolated cases where such conditions may logically exist without being out of line.

White (10) has made a very comprehensive study of water supplies around Chicago and has shown that domestic rates vary from 6.8 cents per 1,000 gal. in Chicago to $1.09 in the small village of Plainfield. For cities with more than 20,000 population in that region the maximum rate is 72 cents per 1,000 gal. Two cities, La Porte and Hammond, the former having a ground water supply and the latter deriving its source from Lake Michigan, have a lowest minimum rate of 4 cents per 1,000 gal., which is less than that of Chicago. Aurora, one of the larger cities, has a maximum domestic rate of 72 cents per 1,000 gal. and a minimum industrial rate of 10 cents. A ratio such as this can hardly be accounted for by any rational method of cost allocation.

In spite of all data available, the writer still believes that the real answer is that many domestic consumers actually pay less than the true cost of service to them while many industrial consumers pay more. In order to bring these comments to a reasonable point for future use it is suggested that a review of rates be made by all systems desiring to modify their rate schedules, and that the points mentioned herein be taken into consideration, particularly where the ratios of slides are far out of line.

Examples of Rates

While many cities experienced water supply growing pains in the twenties, followed by a violent reaction in the early thirties, many of them managed to maintain a fairly even rate all through those periods. The case of Akron, Ohio, as reported on by LaDue (11), is a unique exception, and a tabulation of the rates mentioned by him is shown in Table II.

Rate variations such as these bespeak some vigorous arguments and coupled with a debt service of three quarters of the gross revenue, must have created plenty of headaches for the water department in Akron.

A case where a city has taken over a system and has created well-merited good will is that of Elizabeth, N.J., where a separate Water Commission governs the fixing of rates shown in Table III.

A unique and well conceived schedule of rates is used by the Passaic Valley Water Commission, serving the three cities of Paterson, Passaic and Clifton, and several surrounding com-

TABLE II

Variation in Domestic Meter Rates—Akron, Ohio

Year	Minimum Charge (Quarterly)	Rate per 1,000 cu. ft.	Rate per 1,000 gal.	Remarks
1912	$1.50	$1.00	13.3¢	Before acquisition of system.
1916	3.00	1.20	16.0¢	After acquisition of system.
1921	3.60	1.60	21.3¢	
1933	3.00	1.60	21.3¢	To combat reaction because of gas and electric reductions.
1934	3.60 to 3.20	1.60	21.3¢	Discount for payment.
1941	3.40 to 3.00	1.50	20.0¢	Discount for payment.

TABLE III

Date to	Date	Rate per 1,000 cu. ft. Maximum Domestic	Minimum Industrial
July 15, 1931	July 1, 1933	$3.15	$1.70
July 1, 1933	Jan. 1, 1934	3.00	1.60
Jan. 1, 1934	Sept. 1, 1934	2.85	1.60
Sept. 1, 1934	Sept. 1, 1935	2.70	1.60
Sept. 1, 1935	Jan. 1, 1936	2.50	1.60
Jan. 1, 1936	Jan. 1, 1938	2.50	1.60
Jan. 1, 1938	Jan. 1, 1944	2.40*	1.50*
Jan. 1, 1944	Date	2.30†	1.40†

* Actually in form of refunds of 10¢ based on previous year's purchases.

† Actually in form of refunds of 20¢ based on previous year's purchases.

munities. Low cost water has been quite extensively responsible for the large industrial growth in that area. A small domestic user would pay around 30 cents per 1,000 gal., while minimum rates for the largest consumers go down to less than 7.5 cents, and could reach slightly less than 5 cents for a consumer taking 200 mil.gal. a month or more. There are no less than ten rate blocks within which any large industry can find a reasonable incentive for expansion of water uses.

Other Rate Questions

There is no greater headache in the water supply business than the practice of most cities of allowing free water to public buildings, institutions and even to industries or contractors. The sanest method is to charge everyone. By the same token, a municipal water department may well be charged for the many services in the form of rent, legal advice and other items which it usually receives gratis.

Likewise the inch-square-foot and hydrant charge is the logical method for a water department or company to collect from a municipality for fire protection. In most instances such charges are still not sufficient. The average system should collect at least 15 per cent of its gross revenue from this source. This will bring in a return, sometimes called an equivalent hydrant rental, of nearly $100 per yr. per hydrant.

The conclusions drawn herein are not the result of mere speculation. They have been put to some very practical tests. In the first place, an important court decision on wholesale rates for water in New Jersey was based to a large extent on comparative rates in surrounding municipalities substantiated by evidence that the actual costs were in line with such rates.

Furthermore, the writer has had three occasions within the past two years to use the comparisons set forth herein as a basis of argument for either continuance or changing of an existing rate schedule. In two instances, existing rates were considered proper and were retained, while in the third case a substantial consumer (in this case a small municipality) is now saving over $1,500 annually as a result of recommendations made from studying comparable rates.

It is freely admitted that individual rates may vary over a wide range each side of the results obtained from Equation B and that only by averaging large numbers of results in each population group can a semblance of uniformity be obtained. Nevertheless, these results have proven useful in instances studied by the writer and should be capable of further use by others.

In the period following the last war there were numerous changes in water rates involving serious consideration of increased costs. Thus the price index

between 1913 and the postwar period of World War I was nearly doubled. There seems to be a general feeling that such a situation may occur again, even though few people will offer a positive opinion as to its extent. Consequently, in the postwar period there will probably be a number of readjustments of which meter rates will necessarily be a part.

An analysis of costs will show that debt service on expenditures for additional sources of supply has been to a large extent responsible for high costs of wholesale water. Present interest rates favor capital expenditures and indicate that wholesale rates may go down in the future in comparison to retail rates. These are most important factors that must be considered in modernizing meter rates to meet postwar conditions. It may also be pointed out that the present co-operation of many war industries among themselves will most probably give way to intense competition after the war. Cost of water is often important and may influence decisions on location of industries.

As a result of the study upon which this article is based, the following recommendations are made, even though the text may not fully clarify all of the reasons therefor:

(1) Cost of water delivered at the municipal limits or at the end of transmission lines (i.e., wholesale cost) should first be computed.

(2) Minimum industrial rates should be based on wholesale cost plus a small transportation charge for carrying water through distribution mains. (It is believed that most industrial rates should lie between one-fourth and one-third of the domestic rate.)

(3) Fire protection costs should be derived preferably from an inch-square-foot and hydrant charge.

(4) Domestic rates should be particularly examined to insure their carrying a full share of hidden costs that are too frequently omitted.

(5) All water should be charged for by the water department or company and in turn a water department should reimburse a municipality for all such items as rent, legal and administrative costs.

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Wartime Problems of Jointly Administered Water and Sewage Works

By Wendell R. LaDue, James W. Myers, Jr., John W. Pray and Thos. L. Amiss

Akron, Ohio—Wendell R. LaDue

Introductory Remarks *

THERE is admittedly an ever-increasing trend throughout the United States toward the consolidation of water works and sewage treatment plants under one management. This presents many and varied new problems, all of which are by no means undesirable, however shocking they may appear at first blush.

The merits of joint operation of water works and sewage treatment plants appear to be:

1. A logical handling of two closely related public services.

2. Possibilities for better financing.

3. A more closely-knit engineering division for planning "postwar" projects.

4. More uniformity in policy making.

5. Better controlled public contacts and relations and restoration of public confidence.

6. Closer and more centralized contact with the administrative and legislative branches of the city and in consequence a better utilization of top management.

7. Joint use of office personnel in billing for services rendered. This will increase with sewer rental.

8. Use of a common store room for ordinary maintenance supplies.

9. Joint use of tools, equipment and labor force in emergencies.

10. Joint use of garage and repair shop facilities.

Funds and functions within the "Department of New and Used Water" even under joint administration must be kept clearly defined and separated both in the interest of the public and of the personnel of the Department.

A symposium, Leonard N. Thompson, Gen. Supt. and Engr., Water Dept., St. Paul, Minn., presiding, presented on June 16, 1944, at the Milwaukee Conference by Wendell R. LaDue, Supt. and Chief Engr., Bur. of Water & Sewerage, Akron, Ohio; James W. Myers, Jr., Supt., Water Dept., Kenosha, Wis.; John W. Pray, Mgr. of Utilities, Fort Dodge, Iowa; Thos. L. Amiss, Supt.-Engr., Dept. of Water and Sewerage, Shreveport, La.

* Following the above introductory remarks, Mr. LaDue delivered a paper on the Akron, Ohio, sewage works, the substance of which was published under the title "An Ohio Plan for Financing Sewage Works Improvements," in Jour. A.W.W.A., **36**: 323 (1944).

Kenosha, Wisconsin—James W. Myers, Jr.

Today most water utilities in industrial towns are enjoying an unprecedented era of prosperity. Our sole financial worry is that we are making too much money for our own safety and security. This certainly sounds like a paradox but all water works men know that when a municipally-owned utility begins to build up a surplus it is immediately vulnerable to attack and unless care is exercised the water works surplus is diverted to other channels.

Kenosha is a lake port in southeastern Wisconsin, situated on Lake Michigan, about 35 mi. south of Milwaukee.

During this national emergency Kenosha has become a veritable beehive of industrial activity, producing war materials of all types and descriptions. The principal war products currently being produced include the 2000-hp. Pratt-Whitney engines for high altitude navy fighters, 30- and 50-calibre shells, boat-bunks, wire-rope, airplane cable, stretchers, parachutes, clothing for service men and a host of other items contributing directly to the war effort. Kenosha's manufacturing establishments, 69 in all, are producing materials of vital importance to the Armed Forces and to the war program.

The population of Kenosha is conservatively placed at 51,700; approximately 6 per cent above the official federal census of 1940.

The water works is owned and operated by the municipality. The general control of the water department is vested in the city manager who acts as a Board of Water Commissioners. The direct management and operation is placed with the superintendent.

In Wisconsin all utilities, whether publicly or privately owned, come under the supervision and regulation of the Wisconsin Public Service Commission. The primary function of the commission is to see that the utility renders adequate service at reasonable rates. The commission requires the utility to keep an accurate set of accounts in strict accordance with the accounting principles and procedures laid down by the commission. Annually, the utility is required to file an operating and financial report with the commission on prescribed forms which detail their classification of primary plant accounts.

The Public Service Commission guarantees to each utility a rate structure which will not only be ample to meet all operating and maintenance expenses but will also provide for an adequate depreciation reserve and the payment of local taxes to the municipality.

The commission further requires that the municipality pay for all water consumed by it at the regular established meter rates and that it pay a satisfactory amount for the fire protection service rendered by the utility. Although the utility is actually owned and operated by the municipality it is operated strictly on a business basis keeping its funds separate and distinct from those of the city.

The original works were built in 1894 and new works were erected in 1916 with subsequent additions being made to keep pace with the growth of the city.

The water supply, taken from Lake Michigan, is raised by low-lift pumps to the filter plant and delivered by high-lift pumps to the distribution system, with a standpipe and elevated tank as equalizers. The purification plant has a rated capacity of 14 mgd. The pumping station is fundamentally a steam plant with an electric stand-

by. Three 150-hp. stoker-fired, Wickes vertical water-tube boilers, supply steam to three 6-mgd. high-lift, cross-compound crank and flywheel pumping engines, and one 12-mgd. low-lift, engine-driven centrifugal. The motor-driven units consist of one 15-mgd. high-lift centrifugal, a 15-mgd. low-lift centrifugal and a 6-mgd. low-lift centrifugal. We have 3,000,000 gal. of elevated storage and 3,000,000 gal. of ground storage; 125 mi. of mains and 10,900 services. The total capital investment in utility plant in service is $2,333,000.

The sewage treatment plant, which is owned and operated by the water utility, is of the primary treatment separate sludge digestion type and has a design capacity of 10 mgd. The plant was completed and placed in operation in 1940. The utilities' total capital investment in the plant is $504,651.09.

While the acquisition of the plant was actually a prewar venture and not a wartime problem, the financing of the plant with water utility funds is still of considerable interest to water works men.

The great majority of American cities financed the construction of their sewage treatment facilities by issuing general liability bonds. They provided for their retirement by enacting sewer rental laws which required each householder, commercial enterprise and industry using the sewer system to pay a fee commensurate with the amount of water consumed by them. It was only logical that, when the sewage treatment plant was built, the water department should levy and collect the sewer rental fee along with the water bill. In many cases, this ultimately led to the joint management of the water and sewage facilities, but I know of no other utility that was directly charged with the responsibility of building a sewage treatment plant as an adjunct to the water utility in order to protect the water supply of the community. The entire cost of the plant at Kenosha was borne by the water utility. As many of you already know our plant is no ordinary sewage treatment plant, but a water supply protection works. The adoption of this very dignified and distinguished title cost the water utility over $500,000. The story of how these facilities came to be called a Water Supply Protection Works rather than a Sewage Treatment Plant has no parallel in the annals of water works' history and while the story is not really a war related one it is worthy of repeating to serve as a warning to all municipally-owned utilities which are becoming prosperous during this present war boom.

At the time this diversion of water works funds was contemplated, I being then exclusively a water works manager, bitterly opposed the plan, contending that the water utility belonged to the water consumers rather than the taxpayers since not one penny of tax money had ever been invested in the water works system. It seemed obviously unfair to place a financial burden on 10,900 water consumers which rightfully was the obligation of some 17,000 taxpayers. However, since the transaction is now history, I can look back at the proceedings with less bias. Viewing the matter as a citizen rather than a utility manager, I feel that in our particular case it was in the public interest to finance the construction of the sewage treatment plant with water utility funds. Fortunately it has not jeopardized the financial stability of the utility and was a real con-

tribution to the health and safety of our citizens.

Many years ago Wisconsin and the neighboring states bordering on Lake Michigan decided that it was time to clean up the lake and each state through its respective board of health pledged itself to this end. Accordingly, Kenosha as well as other cities who were discharging raw sewage into Lake Michigan, were directed to discontinue this primitive practice and install adequate sewage treatment facilities.

At the time, Kenosha was not financially able to comply with this directive which required the construction of intercepting sewers as well as a complete treatment plant. Kenosha had just previously bonded itself for the construction of schools and other municipal improvements and was very close to its bond limit. However, the necessity for complying with this order was uppermost in the minds of the municipal planners.

So when PWA came along with its generous grants for public works construction, Kenosha filed an application for a loan and grant to build a sewage treatment plant, offering as collateral bonds issued against the delinquent taxes. The federal government did not consider this satisfactory security and denied the application. Each time new allocations were made to the State of Wisconsin, Kenosha was in the vanguard of applicants always ready with its application for a treatment plant. After several refusals someone suggested that the city bond the water utility to provide the necessary funds for the construction of the sewage treatment plant. The water utility was in a strong financial position and practically free from debt except for a small issue of bonds still outstanding. Any water works man would be indignant at such a proposal to divert water works funds, and I was no exception, but since the city manager, who was also the board of water commissioners, favored the idea I could not afford to be too vociferous in my objections. However, before the plan got too well under way it was possible to convince the manager that while we were financially able to meet the annual payments for bond principal and interest on the proposed issue, that under no circumstances could we be expected to pay the operating expenses. The net result was that the city manager agreed that the operating expenses would be provided out of the tax levy.

After it had been definitely determined that the water utility was financially able to take care of the financing, the question arose as to how to proceed to bond the water utility for the construction of this type of structure.

The city then sought the advice of one of the most prominent bond attorneys in the middle west and was informed that under the Wisconsin statutes a water utility could not be bonded for anything other than a water works structure. It was then that someone dreamed up the fancy sobriquet "Water Supply Protection Works."

The next problem was how to convince the Public Service Commission that a sewage treatment plant in this instance was in reality a water supply protection works. The advocates of this plan appeared before the legal counsel for the commission and by simple academic logic reasoned that the discharge of raw sewage into Lake Michigan was polluting the source of our municipal water supply and that the installation of facilities to treat the sewage and prevent such contamination was a water supply protection

works. Moreover the municipality owned the water utility and should be permitted to exercise some judgment in the administration of its affairs.

The Public Service Commission after due consideration of the city's application approved the construction of a Water Supply Protection Works and the bonding of the water utility to provide the necessary funds for its construction. The bonds were subsequently issued, the plant built and placed in operation.

According to our original agreement, the city has shouldered the responsibility of providing funds for the maintenance and operation of the plant out of the general tax levy. Water revenues are only used for the annual payments of bond principal and interest. Included in our annual budget for the maintenance and operation of the treatment plan is an item of depreciation reserve providing ample funds which are readily available for the replacement of worn or obsolete facilities. This simple precaution obviates any necessity for further drains on water revenues for subsequent capital outlays.

Perhaps the foregoing discussion might have given some the impression that the Wisconsin Public Service Commission let the utility down. That most certainly is not the case for the request came from the city manager who was acting not only as the chief executive of the city but as the board of water commissioners as well; so in reality it was a joint appeal.

As previously stated this may not constitute a wartime problem in finance but because of the attendant circumstances under which the water utility was charged with this unusual responsibility it seemed to warrant an explanation.

More than 3,000,000,000-gal. of water were required to satisfy the mighty appetite of Kenosha and her war industries during this past year. This was an increase of 1,000,000,000 gal. over 1942 and represented a 100 per cent increase over normal peacetime operations. On peak days the pumpage actually exceeded the rated capacity of our filter plant. It was only by extending the rate controllers, valving off the sedimentation basin overflows, and building up a head in the mixing basins that we were able to get a sufficient quantity of water through the plant to meet our requirements. Up to the present we have not curtailed the use of water nor have we regulated sprinkling. Our present pumpage rate, which is 8 per cent above that of a year ago, indicates that the regulation of lawn sprinkling will become a necessity in the very near future. A well-conceived plan of controlled lawn sprinkling is ready to be placed into operation as soon as the need arises.

From a purely operating standpoint we probably should have increased our filter plant capacity to meet this unprecedented industrial load, but since it was only a temporary demand, we did not feel justified in making the capital investment to expand the plant facilities as the present plant is more than adequate for peacetime operations.

Despite the fact that our population has increased about 6 per cent due to the war activity, the normal population trend would certainly not justify additions to our facilities and it would be foolhardy for us to expect a continued growth after the war. Our population actually decreased 3.6 per cent during the last decade and it seems quite obvious to us that Kenosha, along with

other northern industrial towns, has reached an almost static population.

As a consequence no plant additions were made, so every facility is now being strained to the utmost to meet this wartime demand. Every unit of equipment, from boiler feed pumps to the large high-lift steam pumps, is receiving twice as much wear as it normally would, thereby doubling the maintenance and repair work necessary to keep them in first-class operating condition.

Due to the heavy pumping load the old 6-mgd. Prescott cross-compound crank and flywheel pumping engine, which was originally placed in service in 1909 and had been standing idle for years, was reconditioned and placed back in service. This was a major repair job in that it was necessary to remove the plungers and build up the plunger rods with metalized stainless steel. It was our first experience in building up worn parts with sprayed metal, and it promises to be the means of salvaging other badly worn units.

The procurement of coal was another wartime problem which we had not anticipated. Our plant, which is located on the north side of the harbor entrance channel, had, for the past 23 yr. been using high grade eastern fuel delivered by lake freight. Immediately following our entry into the war practically all of the lake carriers were commandeered to haul ore and supplies to the steel mills. As a consequence none of the eastern operators could secure bottoms for the movement of coal and refused to bid on our requirements, which are now just double our prewar requirements. The Illinois operators finally came to our rescue; moving coal to South Chicago by rail and from that port to Kenosha via small 1000-ton carriers (such as sand suckers) and whatever they could charter. We have been getting coal delivered to our dock in this manner ever since.

Meeting the summer sprinkling peak is a real headache, but the threat of needle ice during the winter months is a nightmare. One of Kenosha's larger industries which pumps between 4 and 5 mgd. for cooling and process water has an intake located in shallow water. This intake clogs with needle ice several times throughout the winter and whenever such stoppage occurs the industry's entire load comes on our facilities without notice or warning.

Our intake which is 4700 ft. into the lake and in 35 ft. of water also clogs with needle ice on an average of once every 5 yr. so is a constant source of grave concern.

The State Board of Health refuses to permit the construction of an emergency intake from the harbor entrance channel to the raw water well to take care of us during such emergencies so we are obliged to worry along as best we can.

On January 6, 1943, our lake intake was completely plugged with needle ice. Two 2100 gpm. portable centrifugal pumps and two fire pumps pumped water from the harbor entrance channel into the raw water well. The combined capacity of these pump units, which was 9,000,000 gals., plus the water in elevated storage was sufficient to meet the load and a threatened water shortage was averted. The responsibility of providing continuity of service with this danger lurking in the background is a real wartime worry.

Financing the construction of the sewage treatment plant was only the beginning of our sewage treatment plant problems.

As previously stated the plant was placed in full scale operation in August of 1940. Since it was known that the ratio of industrial wastes to domestic or sanitary wastes was high, the first few months of operation served as a trial period to determine what effect this peculiar mixture of sewage would have on the biological sewage treatment processes. It was not long until we learned that the acid pickling wastes and rinse waters containing copper were not amenable to treatment with domestic sewage. The copper concentration in the sludge pumped from the clarifiers to the digesters had a toxic effect on the bacterial life in the digesters and completely stopped digestion, rendering the plant ineffective and inoperative.

The industry contributing the copper wastes was appraised of our difficulty and asked to pretreat their industrial wastes before discharge into the municipal sewer system. As a temporary expedient the State Board of Health permitted the flow from the 99 in. combined sewer carrying this copper waste to be by-passed directly into the lake without treatment. After this was done the treatment plant functioned properly.

Copper was not our only worry, for this industry, which is working 24 hr. per day on a vital war product, also uses tremendous quantities of oil which when by-passed into the lake contaminated our municipal bathing beaches causing innumerable complaints from the citizenry. Despite the close cooperation of the industry and city in trying to solve this problem, the case has finally wound up in the courts.

Before reaching the courts, however, three hearings were held before the Lake and Stream Pollution Committee and the State Board of Health, at which time the city and the industry presented their cases. Following the hearings these two bodies issued a joint order requiring the industry to pretreat its waste and remove the oil.

The industry thereupon filed a complaint in the Circuit Court of Dane County naming the State Board of Health, the Lake and Stream Pollution Committee, and the city of Kenosha as co-defendants in a suit to test whether or not these two bodies had the authority to issue such an order. The Circuit Court upheld the order and the industry carried its appeal to the Supreme Court of the State of Wisconsin, where the case now stands.

This case is without precedent in the state of Wisconsin and as a consequence it not only involves Kenosha's problem but is also the supreme test of the authority of the State Board of Health.

Public officials throughout the nation have focused their attention on this case, for in the ultimate analysis it will decide whether or not an industry has a legal right to force a municipality to treat and dispose of the industry's wastes, no matter how detrimental they might be to the municipalities' treatment processes.

Personnel Problems

Water and Sewage Works employees are among those 20,000,000 forgotten Americans that Senator Elbert D. Thomas, chairman of the Senate Committee on Education and Labor, talks about in his article in a recent issue of the American Magazine. This is the group that is trapped between rising prices and fixed incomes.

Our employees are living on incomes which have not risen appreciably

since Pearl Harbor, while their taxes, food, clothing and shelter have constantly been going up. The Bureau of Labor Statistics records the rise in the cost of living as 23.4 per cent. Philip Murray, president of CIO, says it is 50 per cent. Whatever the exact figure is these employees have, in effect, had their incomes cut from 25 to 50 per cent.

Contrasted against this, the average hourly wage in Kenosha has steadily risen to $1.175. Jobs in local industrial plants are plentiful. Industrial employment locally is up 300 per cent having risen from 5,272 in 1938 to 16,250 at the present time. Our regular water department personnel, exclusive of the guard service, consists of only 36 persons and the sewage treatment plant personnel including superintendent and chemist still stands at 9 persons.

Until the city council finally granted a $240.00 per year cost-of-living bonus to all city employees, the city was losing men in most departments at an alarming rate. Job security was not quite enough to hold them, but the recent adoption of civil service and the hope of a pension system seems to have stemmed the tide.

During the past year we had an 80 per cent turnover in boiler room personnel alone. Two of the old timers quit because the work had become too arduous; one was lured into industry by high wages; and one went into military service. Two operators at the sewage treatment plant left to take more lucrative employment.

Before the war our average net income after deductions for operating expenses, depreciation, taxes and interest was approximately $65,000.00. Today despite our increased operating expenses for guard service, additional operating supplies and increased interest payments, the net income is approximately $111,000.00 which is a 71 per cent increase. The metered water sales to general consumers in 1943 totaled $253,129.39. Of this amount only $54.15 was uncollected and had to be placed on the tax roll for collection; so wartime collections are no problem. During 1943, 93.7 per cent of our total pumpage was accounted for on customers' meters. The average rate per 100 cu. ft. of water to residential consumers was 10.78 cents; to commercial consumers 8.29 cents; and to industrial consumers 4.86 cents.

The water utility is the fifth largest tax payer in Kenosha. The 1943 tax was $46,746.98.

Up until 1940, our depreciation reserve fund was merely a book entry; to-day it is a real and tangible item. Of our $489,298.51 depreciation reserve fund $400,000.00 has been invested in Series "G" War Bonds and $2\frac{1}{2}$ per cent Treasury Bonds. An additional $100,000 was added to this investment in the Fifth War Loan Drive.

In addition to building up our depreciation reserve the water utility has just credited $239,687.06 to the city's account, canceling the outstanding accounts against the city.

Should our heavy volume of business continue we may be in a position to make other gifts to the city, but we are constantly on the alert to thwart any attempt at unwarranted diversions of waterworks funds which would jeopardize the financial stability of the utility.

Fort Dodge, Iowa—John W. Pray

The subject of this discussion "Wartime Problems of Jointly Administered Water and Sewage Works" can, in my opinion, well be applied to operation of these utilities in normal times. There is, I believe, a definite relation between water supply and distribution and sewage collection and treatment. Water, of course, starts at one place where it is treated and is then distributed throughout the entire community while sewage is collected throughout the entire community and brought to one place for treatment. While there is a definite difference in the treatment, a well-trained sanitary engineer is capable of operating either one or both. Public water supply came into general use years ahead of sewage treatment but not so far ahead of the sewage-collecting system. Much of the best engineering ability in the country has been utilized in the development of the water works systems. Sound business methods have been adopted by most water utilities until today, I believe the water works in most any city will compare favorably with any business of equal size from both the technical and business viewpoint. Certainly no other business is more dependable and few will equal the uninterrupted service rendered by water works.

Water works and sewage systems are, in most cases, owned by the public and it is not surprising that, as the sewage systems have become complicated by treatment plants and rather complex problems of financing, this public should look to the well-organized water works system for assistance and, in many cases, the actual taking over of planning, financing, building and operation of the sewage system. In some cases, the sewage system has always been managed by the water works department. This has been true in my home town of Fort Dodge, Iowa, and when the need for a sewage treatment plant brought about its construction (planning, financing, building and then operation and maintenance) the entire program was administered through the water department. The necessary local and outside help was provided and all cleared through the one office. Ordinances were prepared and the existing billing system changed to provide for the sewage rental bill. These bills are made up as a part of, and collected with, the water bill. All accounting, distribution of expenditures, etc., is handled through the one office and under the direction of one man.

Each subdivision of this joint set up should have a well qualified head. We have a man in charge of the office, the meter shop, the sewage treatment plant, the water plant, the hydro-electric plant, water and sewer systems and garbage collection and disposal system. The principal benefit of this sort of joint management is the interchange of men and equipment and the elimination of duplication of effort. In these times of a shortage of manpower, it is especially beneficial. Exchange of materials as well as equipment is a distinct benefit.

A number of water works managers in cities under 60,000 were asked for their opinion on joint management and, in all cases, they felt that there is a definite benefit in this sort of set up; principally from the economical point of view. All agreed that it is highly important to keep politics out of it which, of course, is true of any municipal utility.

Several consulting engineers were

asked for their opinion on joint management and all expressed themselves as very much in favor of it and several pointed out that municipally-owned water and light plants had been operated jointly in many cities for years successfully.

One Iowa superintendent in a city of 12,000, where joint management has been in force for many years and a fine job has been done, states, as his opinion, that joint management should be confined to cities of population under 25,000.

A superintendent in a city of 8,000 where they have water, light, gas and sewage disposal under one manager, states they are well-satisfied with the arrangement and that much time and money is saved by the interchange of men and equipment and the use of one office for all.

A superintendent of water works in one of the larger cities in Iowa is of the opinion that there is a definite advantage in joint management of water and sewage in cities of moderate size, but could see little value in joint management in the larger cities.

A water manager in a medium-sized city stated, "Joint management would eliminate duplications, promote higher efficiency, keep out petty jealousies and standardize methods." He did not suggest a limit to the size of city which in his opinion, could operate successfully under joint management.

A superintendent in another Iowa City of 15,000 population, who has the management of both water and sewage, states that it is a very desirable arrangement and saves much duplication and expense.

The Director of public property in a city of 80,000 in a midwestern state sees much to be gained by the joint management of water works and sewage as well as any other combination of municipally-owned utilities.

There is no doubt, in my opinion, that local conditions, form of government, political set up, etc., would have considerable effect on the success or failure of joint management of water and sewage works. In one city the water works may be the big problem and in another it may be the sewage works but, given the proper support, a good utility man can make a success of any combination of utilities. Certainly much larger business than any such combination of utilities is being successfully managed under one head and it is reasonable to expect it in municipally-owned utilities.

Shreveport, Louisiana—Thos. L. Amiss

The subject matter of this paper, "Wartime Problems of Jointly Administered Water and Sewage Works," could easily be summed up in one paragraph, or perhaps in one sentence, and still cover the question fairly well. War has frightfully affected all branches of industry—administration, maintenance, operation and improvements of every utility. However, I believe that by subdividing this subject into three parts: (1) Prewar, (2) Wartime and (3) Postwar, we might offer a more interesting approach to the subject.

Early in 1942 I wrote an article for *Water Works and Sewerage*, entitled "Does Water Supply and Sewerage Belong Under One Management" in which I brought out some major facts or problems which would vitally affect both utilities' operating set-up. In part I said: "The highly trained personnel of both of these utilities is reaching a high scarcity mark because of present war conditions. Therefore

seems opportune for cities to study the problem of combining the two utilities, thereby availing themselves of the forced reduced personnel to carry on without subjecting the operation of either to lower efficiency. In other words, bringing all operation under one overhead and direct management, make it possible for the two utilities to function as a single unit and naturally with less men, now at a premium. In our locality women have not yet entered this field; however, we do have them doing clerical work and for two years they have been assisting the chemist. They are carrying on the routine work in the laboratory in a fine manner."

Prior to the war the operation of water works and sewerage in all its phases were in a sense normal, extravagant with abundance of first class labor, even to a surplus, from which a choice selection could be made. In municipal operation a surplus of labor of all kinds is usually maintained. Consequently it took some time before the draft actually had its effect. In the prewar period, problems were normal, labor more or less satisfied and routine operation smooth and pleasant. We could quietly plan our future without having to consult a board to ascertain whether or not certain material could be had and know that what we purchased would be delivered in 30 or 60 or 90 days. In other words prewar problems were usually routine, studied in a calm, sane and economical manner, with full assurance that labor, material and all accessories necessary would be forthcoming. This ease and comfort preceded wartime restriction and tenseness. In our eagerness to be on easy street when the blow struck, overpurchase affected the market, necessitating the control of the market for protection. Some received more than their share. That is a natural consequence.

Wartime problems, hard as they are to work out, are aggravated by every conceivable kind of restriction. Those who were unable to prepare for the worst or had not the foresight simply had to do the best they could. Restlessness and excitement of the people had an effect on the general morale of the employees. Personnel became dissatisfied because of the static condition of low municipal salaries, made more noticeable because of the rapid advances of prices of commodities and the record breaking wages paid inexperienced government workers, together with the protection afforded by Social Security. The municipal employees remained exempt from this security but not from income taxes.

As war plans progress and are formulated wartime problems multiply. The drafting of men became a necessity. One by one the youth of your department are called, leaving for replacement only those who are, under ordinary circumstances, close to the retirement age to select from. As time goes on, things become more and more acute as death steps in to take its toll of old and reliable employees. You are aware that replacements come first from the remnants of your old working staff to man positions of responsibility, leaving possible recruits to fill minor positions.

Retirements from our department to take a more lucrative paying job with the government have been slight. I attribute this (1) to the fact that our employees love their work and were satisfied with the meagre pay increase made by the department; (2) to the non-permanency of the government job; (3) to the bad living condition involved; (4) to the breaking up or interference with the home life, especially where children are concerned.

Our most serious loss was suffered in the engineering corps which involved six men leaving for service—one in the Army, and five in the Navy. The army man is stationed in Australia, two are in the Seabees now in action around New Guinea, three have paid the supreme sacrifice, one in a mission over Germany and two in training in Florida. This has been a severe loss and the problem of replacement appears. It will be a long time before we can fully recover from this loss. Those of our boys who return will find their jobs awaiting them.

Postwar problems will be easier to solve if we take the good features of prewar problem, the good features of wartime problems and co-ordinate them with our best judgment of postwar to the end that postwar problems are handled efficiently, judiciously and honestly for the benefit of humanity. In my opinion the successful handling of postwar problems will require great ability since it will deal both with the rehabilitation of human beings as well as materials. If we can think out our problems from an economic and social but not political point of view the full benefit will be derived. Otherwise chaos can result. It is well to consider these things as soon as possible so that when we have reached the goal of the present catastrophe, plans will have been formulated to bring about normal and routine living. I am afraid that for political reasons the government may restore to the people too soon many of the rights taken from them during the war. Carefully considered return of these rights will balance the back-to-normal man power problem with the materials in order not to flood the market with either.

Wholesale postwar improvements now being advocated should be allocated over a period of time, taking into consideration labor returning from closed down war plants, return of women labor to the homes and most particularly return of demobilized soldiers. Wages appropriate to the time should be fixed and maintained for a sufficient time to regain normalcy. Likewise materials should also be controlled even to fixing the output of manufactured items so that labor and materials will go hand in hand in spreading work over the period of time necessary to insure employment for a long period of time.

The process of rehabilitation is slow and treacherous and is a wartime problem affecting all utilities whether jointly or separately operated.

Summing up the problems of the three periods my personal observation is that joint operation sustained less ill effect than separate operation. In our case we have centralized the operation of the two utilities under one supervisor, alternating the work of the units in such a way as to carry on the work of the other units at reduced personnel. As we operate, it is hard to differentiate between the two departments or units, they are so closely allied and interchangeable. All equipment is available under this setup.

Even war is not without its compensations for in municipal operation there is always a surplus of manpower, but now in wartime with jobs available the reduction of manpower, except in the engineering field, has been a blessing in disguise.

At no time in the life of this country will there be a greater demand for honest, scrupulous and straightforward business-like operation of utilities than will confront us in the near approaching postwar period. If the President could have added another Freedom to his famous four (Freedom from Politics) it would help mightily in this time of trouble.

Management and Control of Public Water Supply Services in the Other American Republics

By Harold B. Gotaas and Robert D. Mitchell

IT is felt necessary to preface this discussion of the management and control of public water supply, services in the other American republics with a brief review of existing water supply practices in the areas under consideration.

Water supplies, in the countries to the south, vary from the most primitive systems to those which compare very favorably with the best modern supply systems. Over vast areas the only supply is the nearby river or spring to which the women and children of the family make regular trips to fill the 5-gal. gasoline tin, the gourd, or the clay jar, as the custom of the locality dictates. Those better off financially may buy their water from peddlers using water carts filled from the same source. Where the source is conveniently located, this system may be used for communities with as high as 5000 inhabitants. In such cities laundering of clothes and bathing are often done in the same stream or spring from which the water supply is taken. The first progress comes when the city finds ways of developing a spring or diverting part of the flow of a mountain stream. Often such a development was made in the time of the Spanish Colonial Empire and consists of a gravity masonry aqueduct leading into the public square where the water spills out in a fountain. More modern systems utilize pressure piping but frequently all but the well-to-do collect their drinking water in containers at the public fountain. The larger cities have developed surface supplies and water is supplied to the houses or public hydrants through distribution systems of galvanized iron or cast-iron pipe. Unfortunately, in too many cases, breaks and joint leaks are numerous. Many sources cannot supply the demand placed upon them, either through lack of water or lack of pumping equipment. At times of high demand such shortages result in negative pressures in some parts of the system. To conserve water some cities cut off the distribution system at night to allow storage reservoirs to fill. Thus, while the lower portions of the system still have water, the higher elevations operate at negative pressures, and where, as is not infrequently the case, the water line runs exposed in a ditch carrying sewage, great danger exists that contaminated liquid will be drawn into the main. The danger is

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not absent even when such obvious defects do not exist. It should be noted that while these water shortages exist the systems are largely unmetered and operate, as shall be mentioned later, with a large percentage of waste.

Intestinal Disease Statistics

It is difficult to assess from a health standpoint the effect of a good water supply in a tropical area because of the prevalence of a great many intestinal parasites, some transmitted by water and some by other means. Too few reliable data exist to make it easy to evaluate its effect. As a part of the work of the Co-operative Inter-American Health Services, such an evaluation is being attempted in certain small communities hitherto without satisfactory water supplies or excreta disposal. In these towns stool surveys are being made of a representative sample of the population before the installation of sanitary works and will be repeated at intervals to determine the effect on the intestinal population. A preliminary survey in one city, considerably larger than those referred to above, yielded the following results:

	%
Positive for parasites	85.4
Ascaris lumbricoides (Eelworm or roundworm)	65.8
Necator americanus (Hookworm)	44.3
Trichuria trichiurus (Whipworm)	28.8
Endamoeba coli	18.9
Endamoeba histolytica (cysts) (Causative agent of amoebic dysentery)	5.2
Others in lesser percentages	

The percentage of *E. histolytica* is interesting in view of the estimates on the part of various authorities in the United States of an incidence of from 8 to 10 per cent and even higher in this country.

In Venezuela and in parts of other countries a serious problem is created by the presence of a snail which acts as intermediate host of *Schistosomiasis mansoni* (the blood fluke) in waters used for washing clothes and bathing. In some areas of Venezuela, in the poorer sections of the towns, as high as 62 per cent of a sample of 60 persons were found infected with *S. mansoni*.

Epidemiological studies are only now beginning to be made in many of the areas under consideration. Consequently the difficulty of correlating the presence of water-borne disease with the condition of the water supply system is obvious. Typhoid fever is exceedingly common and many methods of transmission exist. Improving the water supply will not entirely solve the problem. Nevertheless, as has so often been observed, an improved water supply will have an extremely great effect on the overall health of the community.

Table I gives death rates from reported cases of typhoid fever. The values given are probably low, particularly in rural areas, because of unreported deaths. Not given in the report from which these figures are taken are data on Argentina. Buenos Aires reports a mortality rate of 1.7 per 100,000 in 1941.

Financing and Development

In the majority of the countries being considered, the financing of water supply improvements is primarily a function of the federal government. In a few countries some of the older supplies were constructed by private companies, but in most cases the federal or state government is carrying on the work today and at the same time is gradually acquiring the private properties. The trend toward govern-

TABLE I

Typhoid Mortality Rates in Latin American Countries

(From "Biostatistical and Epidemiological Report on the Americas"—Feb. 1943)

Country / *City*	*Deaths per 100,000 pop.*	*Year*
BOLIVIA		
La Paz	193.0	1933
COLOMBIA	27.6	1940
Bogota	22.0	1940
COSTA RICA	9.5	1940
San Jose	11.0	1939
CHILE	14.3	1941
Santiago	17.5	1939
ECUADOR	13.7	1940
Quito	35.0	1938
EL SALVADOR	3.5	1941
San Salvador	16.8	1942
GUATEMALA	6.7	1940
Guatemala City	37.6	1940
HONDURAS		
Tegucigalpa	27.5	1940
MEXICO	42.5	1941
Mexico City	21.4	1941
NICARAGUA	9.3	1941
Managua	68.0	1939
PANAMA	6.0	1931
Panama City	0.0	1938
PARAGUAY	15.0	1941
Asuncion	30.8	1941
PERU		
Lima	12.8	1941
DOMINICAN REPUBLIC	11.0	1941
Ciudad Trujillo	10.5	1941
URUGUAY	9.5	1939
Montevideo	6.1	1941
VENEZUELA	21.3	1940
Caracas	21.0	1941
UNITED STATES	0.8	1941
Washington	0.4	1942

mental ownership of water utilities has become extremely widespread in Latin America, perhaps due to the fact that in many countries all taxes go to the federal government, which in turn finances improvements. The following table indicates practice in financing:

TABLE II

Most Common Methods of Financing Water Supply Improvements

Type of Financing	*Number of Countries*
Federal Funds	13
Local Funds	3
Combination	4

Interesting methods of financing are used in several countries. In Colombia, for example, for the most part the construction of water supplies is financed by the combined funds of federal, state, and city governments. The tax money allotted to municipal improvements is controlled by an organization known as the Fomento Municipal. This organization earmarks a part of the money for the construction of water works and sewerage. The usual practice is for the federal government to furnish 60 to 70 per cent of the costs. Seventy per cent is given by the federal government when the municipal budget is less than twelve thousand pesos ($6850) a year. The state and city together make up the remainder. The city's share depends entirely upon its state's laws. In some states the financing of this share is handled entirely by the state, while in other special cases where the city has a large budget the city pays the larger portion. In the case of water supplies for ports and border towns the federal government pays the entire cost. In other special cases laws are passed permitting the government to pay the total cost.

The federal government gives its share in materials rather than money; if the value of the materials does not equal the government's share, the bal-

ance is paid in cash. This system effects a saving for the government, since the materials are purchased in large lots, and it also provides a definite control on the quality of the materials inasmuch as these are purchased under the specifications of the Engineering Department of the Ministry of Labor, Health and Social Welfare.

In Mexico three methods of financing are in vogue. Where it appears financially possible to obtain a satisfactory return on the investment, the Banco Hipotecario constructs a water supply system in a community and retains ownership of the system until the investment is amortized. If additional improvements are made, their cost is added to the original investment charge. After the investment is paid off the system may be turned over to an organization known as the "Committee for Public Improvements" for future operation. In selected communities the Federal Department of Health, through the Division of Potable Water, develops water supplies and operates them. These communities are also preferably those where a satisfactory return on the investment may be obtained. A system financed in this manner may also be turned over to the "Committee for Public Improvements" for operation. Local financing is only done in the case of several of the largest cities in the country, or by the state government which may develop and finance the system and turn it over to the "Committee for Public Improvements" to operate. At the present time the Banco Hipotecario is believed to have constructed the greatest number of systems in Mexico.

Private ownership is of minor importance in most countries, although in Cuba 31 out of 40 supplies are owned and operated by private companies. Six private companies are operating in Colombia, although plans are under consideration to purchase these systems. Other private systems are operated on a limited scale in Guatemala, Honduras, Nicaragua, Panama, and elsewhere. They are relatively few in number, however, and it is probable that there are no more than 75 privately owned and operated municipal supplies in all of Latin America.

While a considerable number of supplies have been designed and built by private organizations, as a whole present-day studies and plans are made by either the Ministry of Public Works or of Public Health. The Ministry of Public Works is more important in this respect, and in only a few countries does the Ministry of Public Health play an important part in designing new projects. Foreign consulting engineers are occasionally engaged by either ministry to aid in making the studies and designs. The consulting water supply engineer as he is known in the United States is almost nonexistent in most of the countries. An outstanding exception is Colombia where about 80 per cent of the design work is done for the ministry by private consulting engineers or contracting firms. Even in Colombia, however, the relationship of consulting engineer to client is modified by the fact that the client is essentially the state rather than the municipality.

Management and Control

Operation and management of water supplies is by the federal government in about half of the countries. In the balance, operation is by the local authorities, or partly by local and partly by federal. A few supplies, such as

those in Cuba where 80 per cent of the supplies are privately owned, are still operated by private companies.

In the cases where the Ministry of Public Works operates the supply, federal control is absolute, although that does not necessarily mean that careful sanitary control is always practiced. Where operation is local, the federal government usually maintains only an advisory control over the operation of the system. Local employees can and often do disregard the advice of the federal engineers. Depreciation and accounting practices as used in the United States are seldom encountered in Latin America. Methods of financing and operation in the past have not encouraged such practices.

Charges for water vary greatly. Meters are not widely used and traditional methods of operation have persisted. For example the older distribution systems were designed as continuous flow, low pressure systems, using masonry main conduits, connected with gravity distribution boxes from which the water was distributed to the adjacent water takers through small metal pipes. The flow line of the distribution box was placed 10 to 12 ft. above the ground level and the control of the quantity of water delivered to each water taker was made by throttling the valve on the distribution pipe. Under this system, there is no saving of water if one water taker shuts off his connection. It simply increases the quantity of water flowing to the other water takers in the same block, or causes the distribution box to overflow.

Even with more modern pressure pipe systems, the "meter" is the throttled valve which often discharges into a water box or tank on the taker's premises. Since in many towns water is turned off at night, the water is left running continuously during the day in order to have a full water box as much of the time as possible.

Outside of Chile, which is estimated to have 90 per cent of its municipal water supplies metered, Uruguay, where the larger supplies are metered, and Bolivia, whose five public water supplies were originally private companies, only a few cities use modern water meters. Good statistics on the quantity of water used per capita are largely lacking, due to the absence of metering, inadequate population data, and to the fact that so many people get their household supply of water from public fountains.

Metered consumption of water runs from 2 to 75 gpd. per capita, while unmetered may go as high as 200 gpd. per capita, due largely to the waste incurred with continuously running services. In many cities it is reported that the consumption is all of the water available. In such cases, obviously, little significance can be attached to consumption figures.

To compare water charges in several Latin American countries a hypothetical water bill has been figured for a residence using 3750 gal. of water per month through a ½-in. service connection. The resulting data are shown in Table III.

The rate schedule followed in Bogota, Colombia, is interesting in that it varies with the value of the property (see Table IV).

Water Supply Practices

Outside of Argentina, Brazil, Chile, Colombia, Mexico, Uruguay and Venezuela, there is very little treatment of water except occasional inadequate chlorination. Argentina, Cuba, Uru-

TABLE III

Cost for 3750 gal. of water per month, ½-in. connection

Country	*Dollars*
Brazil	0.20 to 2.00
Chile	0.21
Colombia (Bogota)	0.90 to 8.50 depending on value of property served
Costa Rica	0.18 to 0.54
Dominican Republic	2.00
Ecuador	0.44 to 2.19 (flat rate)
Guatemala	0.75
Haiti	0.80
Honduras	0.50 to 1.00 (flat rate)
Mexico	0.20 to 0.40
Nicaragua	1.00
Panama	1.00 (flat rate); 1.33 (metered)
Peru	0.17 to 0.22 (metered)
Uruguay	1.12 to 1.50
Venezuela	2.40 to 3.00 (flat rate)

guay and Panama are the only countries using ground water to any great extent. Surface waters, rivers and springs, sometimes supplemented by infiltration galleries, form the major portion of the supplies. According to the 1941 report on "Sanitary Works of the Nation," Argentina has some nine rapid sand filter plants and eleven slow sand filter plants. Brazil reports at least 72 treatment plants of various types but inadequate statistics undoubtedly make this figure low. In Chile twelve communities are served by rapid sand filters and eight by slow sand filters. Three pressure type filtration plants operate in Cuba. Colombia has two pressure filter installations, 22 rapid sand filter plants in operation and eight more under construction. Mexico has seven rapid sand filtration plants and a number of slow sand filter installations. Of Uruguay's public water supply systems, 82 are filtered and 38 are from wells. Venezuela has four

TABLE IV

Rates—Without Meters
(Values in U.S. Dollars)

Diameter of Pipe in Inches	Valuation of Property							
	0 to 570	570 to 1,710	1,710 to 5,700	5,700 to 8,550	8,550 to 10,400	10,400 to 17,100	17,100 to 20,800	Over 20,800
⅜	0.57	0.68	1.03	1.43	2.28	3.42	4.56	5.70
½	1.17	1.37	2.11	2.91	4.67	7.01	9.35	11.69
¾	3.22	3.88	5.24	8.09	12.94	19.38	25.88	32.21
1	6.61	7.98	11.91	16.82	26.51	39.73	53.58	66.12

Rates—With Meters
(Values in U.S. Dollars)

Minimum	0.51 for 706.3 cu.ft.	0.57 for 706.3 cu.ft.	.86 for 1059 cu.ft.	1.37 for 1236 cu.ft.	2.00 for 1412.6 cu.ft.	2.85 for 1765.7 cu.ft.	3.99 for 1765.7 cu.ft.	4.85 for 2118.9 cu.ft.
Excess	.0228 per 35.3 cu.ft.	.0285 per 35.3 cu.ft.	.0342 per 35.3 cu.ft.	.0399 per 35.3 cu.ft.	.0456 per 35.3 cu.ft.	.057 per 35.3 cu.ft.	.057 per 35.3 cu.ft.	.056 per 35.3 cu.ft.

water filtration plants, two in operation and two under construction.

Design standards and practices quite generally follow those of the United States, although less mechanization is ordinarily used. Mechanical equipment purchased in recent years has largely come from this country. Early in the century much pumping equipment and pipe was of European make and even a few years ago European cast-iron pipe could be bought more cheaply in many localities than that made in the United States, and had the additional advantage of being in metric sizes.* It is often found that pumping and pipeline equipment is of European make, while filtration and chlorination equipment more commonly originates in the United States.

Some typical examples of water supply and purification practices are included in the following paragraphs.

Argentina. Buenos Aires (population 2,500,000). Water is taken from the Rio de la Plata by ten electrically-driven pumps which pumped an average of about 285 mgd. during 1941. Alum, for coagulation, is added to the suction of the raw water pumps, which then pump the water to the Palermo filter plant. The turbidity of the raw water varies from 10 to 500 ppm. and the settled water from 1 to 8, and is usually under 5 . The sedimentation tanks have a detention period of about $3\frac{1}{2}$ hr. Following sedimentation, the pH of the water is adjusted with lime, and chlorine is added. Breakpoint chlorination has been used at this point when conditions warranted its use. Both slow and rapid sand filters are used but the older slow sand filters are now primarily used as standby units and in 1941 were only operated about 2 per cent of the time. With normal chlorination post-chlorination is practiced but when "breakpoint chlorination" is used no addition is required to maintain a residual.

Bolivia. Cochabamba (population 100,000). Water is obtained from two sources. An infiltration gallery in the valley of Cochabamba collects part of the supply which is carried by an 18-in. concrete pipe to a collection chamber which also receives water from twelve wells. The combined waters reach the distribution reservoir through two 14-in. concrete pipelines. From the distribution reservoir two steel mains carry the water to the city. There is no treatment or disinfection.

Colombia. A number of plants in Colombia were designed by engineering firms in the United States or by engineers trained in the United States. Among such plants the Vitelma plant in Bogota, the Barranquilla plant and the Cartagena plant are worthy of mention. They will not be described because of their similarity to plants in this country. Most of the English plants, of which there are about five in operation, are of a patented type known as the "Patterson Water Treatment Plant." The one at Buenaventura (population 30,000) is typical. There are two intakes, one on the Dagua River about 11 mi. from town and the other on the Escalarete River about 19 mi. away. The water flows to an open reservoir 9 mi. from town. The reservoir has an area of 8610 sq.ft. and a depth of 8.9 ft. and acts as a plain sedimentation basin. The water flows from there to the plant, which it enters over a rectangular weir which serves as a flowmeter. Alum and lime

* The metric system is widely used in South America.

may be added at the weir and are supposedly mixed in the narrow flume which follows the weir. The water then enters sedimentation tanks with twin hopper bottoms, operated in parallel, with a theoretical detention period of 2½ hr. From the sedimentation basins the water can be discharged to any or all of three sand filters. The filters are identical, each having a capacity of 0.684 mgd. They are air washed with a small amount of water being used to remove the dirt. The filtered water is chlorinated. Chlorine gas is released into a vertical column of water to put it into solution. The resulting solution is then fed through an orifice box. The water is aerated and lime is added for pH correction before the water enters the clear well. Three high-service centrifugal pumps are used to pump to the distribution system.

Dominican Republic. Ciudad Trujillo (population 75,000). The water supply of Ciudad Trujillo is taken from the Rio Isa at a point 24 mi. northwest of the city. The watershed covers 14 sq.mi. and is uninhabited. The terrain is mountainous and heavily covered with vegetation. As would be expected, runoff is rapid due to the steep slopes. The minimum flow in the stream is reported to be approximately 25 cfs. and the flood flows probably approximate 15,000–20,000 cfs. The original supply was obtained by impounding this and treating with chlorine only. In 1938 it was decided to clean the impounding reservoir because of the deterioration in water quality which had gradually developed. This undertaking was completed in early June after the removal of some 75,000 tons of sediment. About fifteen days later a heavy rainstorm (about 14 in. in 72 hr.) caused the caving of a large sand hill upstream with the result that the entire reservoir was filled to the elevation of the dam spillway. The material washed downstream by the storm was largely sand and gravel with a minimum amount of organic matter.

Before cleaning the reservoir of sediment, it had been necessary to construct an infiltration structure above the reservoir for temporary use. This was accomplished by underdraining a section of stream bed with 8-in. vitrified clay pipe connected into a manifold. The sand depth above the manifold was about 4 ft. A temporary concrete flume had been built to divert the effluent from this gallery to the main aqueduct leading into the city.

Following the storm it was found that the underdrains were covered to a depth of 8 ft. In addition the control house and flume were also buried. As it was necessary to provide the city with water quickly, the infiltration structure was again placed in service after clearing the control house and flume and replacing sections of the main line to town which had been damaged. Upon resuming service after an interruption of two weeks, the flow through the filter was found to be about 75 per cent of the original flow through the 4-ft. sand depth. To supplement this supply, the underdrains were immediately extended. The total cost of the old filter and the extension was about $18,000 and it now has been in use for about 6 yr.

The original design of the temporary infiltration system was based on an assumption of .092 gpm. per sq.ft. This capacity was never realized, however. At present it is operating at a rate of 3200 gpm. With a total estimated

area of 75,350 sq.ft. this amounts to about .043 gpm. per sq.ft.

At present there is another infiltration gallery under construction which is unique, to say the least. It consists of two 48-in. perforated pipes each 120 ft. in length surrounded by a selected gravel filter, located parallel to and just to the rear of the dam spillway. It is expected that the new installation plus the old will give a total capacity of 10,000 gpm.

Ecuador. Quito (population 150,000). The Quito water supply is composed of two separate systems, one a surface supply, and the other a spring-fed infiltration gallery collection system. The surface supply consists of two parts; the first is water obtained from the ravines on Pichincha Mountain, and the second a similar supply from Atacatzo Mountain. The first furnishes a minimum of 620 gpm. during the dry season, conducted through 9 mi. of gravity concrete line. The Atacatzo supply is brought into the city through an open canal, some 26 mi. in length, and furnishes a minimum of 1110 gpm. These two supplies are combined at a plant just above the city where the water is treated by plain sedimentation, two successive sand filters which operate at a very high rate, and uncontrolled chlorination. The distribution system carries an exceedingly high pressure in small pipes.

The second system is obtained from infiltration galleries and is pumped directly into the main system. Chlorination is practiced. This supply operates at the rate of 1585 gpm. and is water of good physical, chemical and bacteriological characteristics.

Haiti. Port-au-Prince (population 150,000). This city is served by water from seven springs. It is entirely a gravity supply with an intermediate storage reservoir of 2.8 mil.gal. capacity. The intake is unprotected and hence is a potential danger point. The water is inadequately treated with chlorine and partially treated with Calgon in an attempt to minimize deposition of calcium carbonate in the mains. The distribution system is in poor repair and subject to contamination. The capacity of the system is about 7 mgd.

Honduras. Tegucigalpa (population 50,000). There are two sources of supply, one for the Tegucigalpa section and one for the Comayaguela section of the city. The first comes from two mountain reservoirs located some 9 mi. north of the city. The water flows by gravity to three large settling basins located about 1000 ft. in elevation above the city. From here the greater portion of the water is discharged through a hydro-electric plant, chlorinated and passed into three distribution reservoirs. The Comayaguela supply comes from a reservoir on the Guacerique River about 6 mi. south of the city. The water flows by gravity to a settling reservoir from whence it flows to two open distribution tanks. At the present time slow sand filters are under construction for this supply.

Mexico. Mexico City (population 1,750,000). Mexico City is supplied from various water sources, principally from springs near Xochimilco, the water originating from rainfall over the Pedregal lava beds southwest of the city. This source supplies approximately half of the water for Mexico City. In the city and immediately adjacent to the city are approximately 2800 registered deep wells which supply a quantity of water about equal to Xochimilco. A large number of these wells are privately owned by individ-

uals or real estate development corporations for supplying private property. The Xochimilco supply is chlorinated and it is understood that ammonia is also used at times.

Water service pressure varies throughout the day and at times certain areas are without water. For this reason all buildings and residences are equipped with balancing tanks on top of the building to carry over during the low-pressure period.

Because of damages from earthquakes and settlement of the earth, pipelines are subject to almost continuous damage and low-pressure conditions in the mains or vacuum periods in the lines create the possibility for drawing pollution into the mains, resulting in the possible delivery of polluted water to the consumers at some times.

Nicaragua. Managua (population 76,000). The water supply of Managua is taken from Laguna Asososca, a crater lake 300 acres in area and 3 mi. southwest of the city. The lake is surrounded by a steep escarpment rising 300 to 500 ft. above the water surface. Soundings have indicated depths of over 600 ft. The surface lies 4 to 10 ft. above the level of Lake Managua, and it fluctuates more or less in proportion to the variations in the level of the larger lake. The average storage volume has been estimated at 8.7 bil. gal. The municipal pumping station is located on a shelf a few feet above the lake and contains three pumps discharging against a head of approximately 340 ft. into a circular concrete reservoir of about 1-mil.gal. capacity located on the other side of the crater wall. About 5.5 mgd., the capacity of the pumping station, is being pumped without a noticeable effect on the water level of the lake. This amount of water is insufficient for the needs of the city. All pumps are being operated about 23 hr. per day, but nevertheless it is necessary to cut off water service to the city about 6 hr. per day. Chlorination is the only treatment.

Peru. Lima (population 500,000). The Lima supply has a capacity of 26 mgd. Half of the water is taken from the Rimac river and half from infiltration galleries along the river. The water is settled, coagulated, settled again and chlorinated. Chlorination at present is inadequate, but plans have been made to remedy this defect after the war.

Uruguay. Montevideo. Montevideo's water purification plant is located approximately 34 mi. northwest of the city on the Santa Lucia River. The first unit of this plant, consisting of steam-operated low- and high-lift pumps, sedimentation chambers, and slow sand filters, was constructed in 1870. In 1930 the original filters were abandoned for the rapid sand type, as part of a remodelling program which also included the installation of three diesel-driven high-pressure pumping units of 5.3 mgd. capacity each.

Raw water is pumped from a low dam approximately 6.6 ft. high on the Santa Lucia River. Five cities, with a combined population of approximately 72,000 persons, are located on the watershed. Three have partial sewage treatment and the balance are not sewered. The tributary watershed has an area of approximately 308 sq.mi. Three steam-driven pumping units discharge the raw water to six settling basins, each 199 × 131 × 13 ft. in size. Alum in solution is added to the raw water as it discharges into the distribution chamber which controls the water

flowing to the settling basins. The settled water flows to one of two filter units, each containing fourteen filters. Each filter is 17.7 ft. square, is equipped with porous plate underdrains and uses compressed air in backwashing. Approximately 39 in. of sand is placed over approximately 1 in. of gravel. Sand is not graded, but care is taken in the selection of natural sand which is usually obtained from a beach near Punta del Este on the Atlantic Ocean. Filters are commonly washed when a 10-ft. loss of head is reached, normally after 48 to 70 hr. of operation. Wash water is supplied from a 20,000-gal. steel tank enclosed in concrete above the chlorinator house. Two solution feed chlorinators are used at all times. Ammonia gas in proportions of one part of ammonia to three of chlorine is added before the chlorine is applied and before the water reaches the clear well. Lime is added to the filtered water to raise the pH to 8. Elevated storage is provided by nine reinforced concrete water tanks with a combined capacity exceeding 26 mil.gal.

Venezula. Maracaibo (population 136,000). At Maracaibo, in the oil producing area, ground water high in iron and rather hard is treated by aeration, chlorination, sedimentation, and filtration.

Bacteriological and Chemical Control of Water Quality

In a general way bacteriological and chemical control have been touched on in the preceding paragraphs. Most of the waters are surface waters and are not excessively hard, hence virtually no softening of water is practiced. Only a few countries have any strict bacteriological control. Usually there is no active federal control. Although some plant operators are familiar with "Standard Methods of Water Analysis," a standard comparable to the U.S. Public Health Service "Drinking Water Standards" is not in common use. There is a growing tendency in many countries toward control of water quality by the Ministry of Public Health, although in a majority of the countries little prograss has been made.

Only in Colombia has any specific training been reported in the way of short courses for plant operators. In most of the countries the operator is trained on the job, although in a few, men are trained in the better plants of the country and then sent out to operate small installations. In a number of countries plants are operated by engineers who train their subordinates in the mechanical phases of the operation procedure.

Conclusion

The Public Health and Public Works authorities of the other American republics know the deficiencies of their water supplies and are striving to bring them up to standards of present-day thinking. The number of supplies involved, including cities which should have them, but do not now, is very large. The rate of development to be expected in the future depends upon the economic status of the area after the war and a continuation of the present demand for better water supplies. Some co-operative water supply development is being provided now through the Inter-American Co-operative Health Service, but the amount of necessary work is large and the present material and supply problems so difficult that only a relatively small amount of improvement can be expected in the

near future. Under a proper combination of conditions great advances are possible in the postwar era.

The material presented here has been compiled from a series of reports made by the Chief Engineers of the Institute of Inter-American Affairs field parties in the various countries with which the Institute is co-operating. Additional information has been obtained from the annual reports of the "Obras Sanitarias de la Nacion" of Argentina, and from J. A. Cosculluela, Consulting Engineer, Havana, Cuba.

Erratum

Jackson, L. A. Historical Development of the Fire Hydrant. Jour. A.W.W.A. **36**, 928 (Sept. 1944).

Figures 15 and 21 were derived from photographs furnished by Arnold C. Wildsmith, Northern District Engr., Manchester, England.

Item *2* listed in the first column, page 938, erroneously includes Fig. 17 as a "sluice valve hydrant." It is correctly captioned on page 939.

Mr. Warren Y. Kimball, whose name is included in the list (page 950) of persons who co-operated with the author in assembling information, is an Engineer of the National Fire Protection Association, Boston, Mass., and is not associated with the National Board of Fire Underwriters.

The Research Laboratories of the Melbourne and Metropolitan Board of Works

FOR some time prior to 1939 it had been felt that the Melbourne and Metropolitan Board of Works required additional research facilities for dealing with many problems associated with its water supply and sewerage activities. The necessity of providing additional water storages and contemplated improvements in methods of sewage treatment rendered it essential to increase the technical staff of the Board, and as much of the work was closely related it was deemed desirable by the Engineers of Water Supply and Sewerage to house the necessary staff and equipment in a modern laboratory under a common roof.

The proposal to erect a Research Laboratory took definite shape in March 1939 when the Water Supply Committee, on the recommendation of the late Mr. A. E. Kelso, Engineer of Water Supply, approved of the preparation of preliminary building plans. The final structural plans were completed in November 1940. These provided for a brick and concrete building of two stories and a basement, with provision for a future third floor when required. Building operations were commenced in March 1941. It was officially opened on June 3, 1943.

In this building it is proposed to continue and extend the following investigations:

1. *Pipe Coatings.* Special attention to the safeguarding of one of the Board's largest assets, the underground steel water mains, by protective coatings was initiated in 1930, and the progress made to date has already won recognition overseas.

The additional facilities now provided will have the double function of scientific control of the manufacture of pipe-coating materials and of pure research directed towards their improvement. The laboratories will also make it possible to undertake the testing of bituminous substances for other purposes, such as roadmaking and pipe jointing.

2. *Hydraulic Engineering.* Much of the progress in hydraulic engineering, particularly in recent years, has been due to the use of models. Some authorities, notably the U. S. Bureau of Reclamation, submit all their important designs to exhaustive model tests before plans are adopted.

In the large laboratory provided for hydraulic investigations it will be possible to study the hydraulic behavior of models of various proposed structures

A description from the program of the official opening on June 3, 1943, of the Research Laboratories of the Melbourne and Metropolitan Board of Works, Melbourne, Australia, submitted to the A.W.W.A. on July 19, 1944, by W. A. Johnson, Electrolysis Officer of the Board and Supervising Engr. for the Board on the construction of the Laboratories.

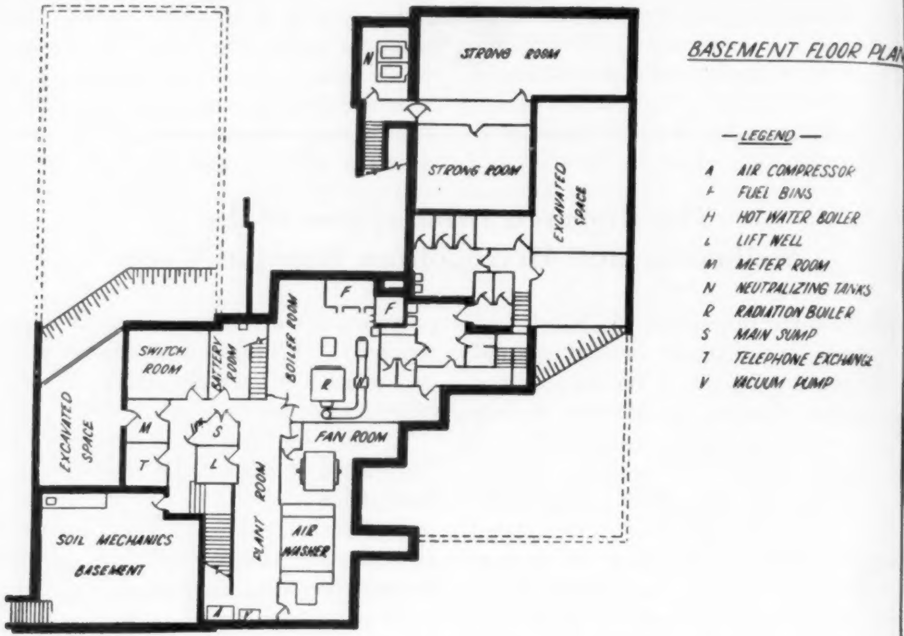

Fig. 1. Basement-Floor Plan from Official Program

for water supply, sewerage, stormwater drainage, and river control purposes. Experimental work can also be carried out on plumbing systems, flow meters, and special fittings.

3. *Electrolysis.* Although considerable progress has been made in devising methods for reducing damage caused by electrolysis, there is a definite need for further research, particularly into the more recent methods of achieving mitigation. Overseas, much attention has been paid to underground corrosion, and in recent years it has been realized that soil bacteria can play quite a large part in the deterioration of buried metallic structures. Considerable work remains to be done, however, and it is felt that the Board should keep abreast of these developments. It is likely that service pipe practice will alter substantially after the war, when new materials, which have been developed recently, become available for general use. Research will be necessary to ascertain which of these materials is most suitable.

4. *Soil Mechanics.* Soil mechanics refers to the study and use for agricultural and engineering purposes of materials resulting largely from rock weathering. Although soil mechanics represents one of the earliest arts in engineering, the complexity of the principles involved was imperfectly appreciated until recently, when it was realized that soil properties could not be predicted from a few simple tests like those performed on steel, but that the characteristics of each soil must be separately examined.

The major soil problem at present confronting the Board is largely concerned with rolled-fill earth dams. The research of the late Engineer of Water

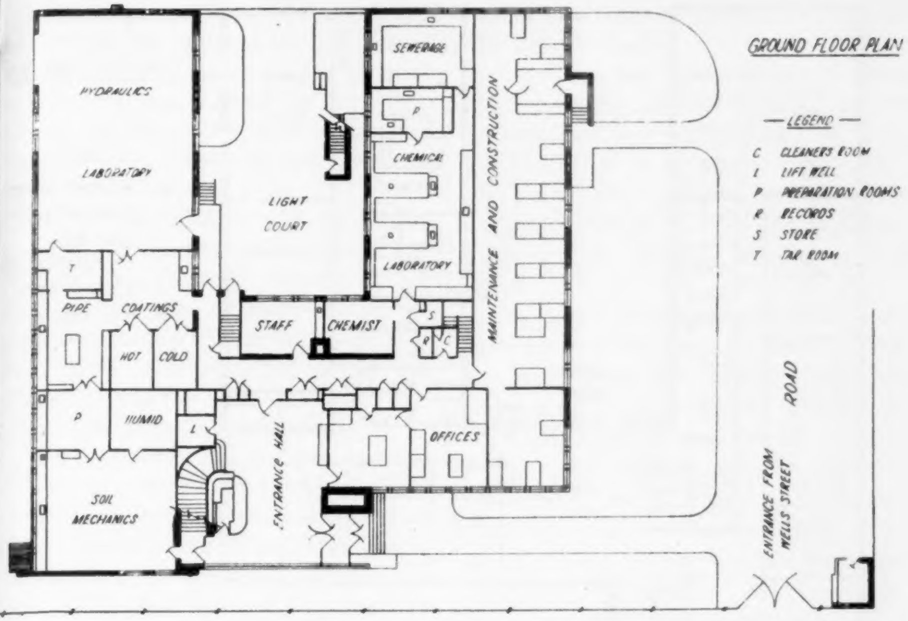

FIG. 2. First-Floor Plan from Official Program

Supply (Mr. A. E. Kelso), which resulted in the use of an optimum moisture content for the construction of Silvan Dam, was initiated about the time that similar work was being carried out in California, but the facilities available to the Board in recent years have not permitted parallel progress. Economical construction of earth dams requires the incorporation of materials from areas adjacent to the site. These must be investigated to verify whether they can be compacted to form a dense, stable and watertight fill under any probable conditions of saturation and loading. While some of the tests can be completed in a field laboratory, others require more extensive equipment and controlled atmospheric conditions, and should be conducted in a central laboratory.

The principles of soil mechanics are applicable to many problems in connection with sewerage construction, and use of the laboratory for this purpose will also be made.

5. *Chemistry and Bacteriology.* Owing to the inter-relationship between chemical and bacteriological processes in sewage problems it is generally desirable to carry out chemical and bacteriological investigations in conjunction. The main subject of investigation at present is the corrosion of sewer structures by hydrogen sulfide gas arising from the sewage, and much of the experimental work centers around an experimental plant in which the sewage is so treated as to prevent this type of corrosion. Additional aspects of this investigation, including a study of the resistance to corrosion of cements, concretes, and other construction materials, will be put in hand in the new laboratories. This is a problem which occurs in many sewerage

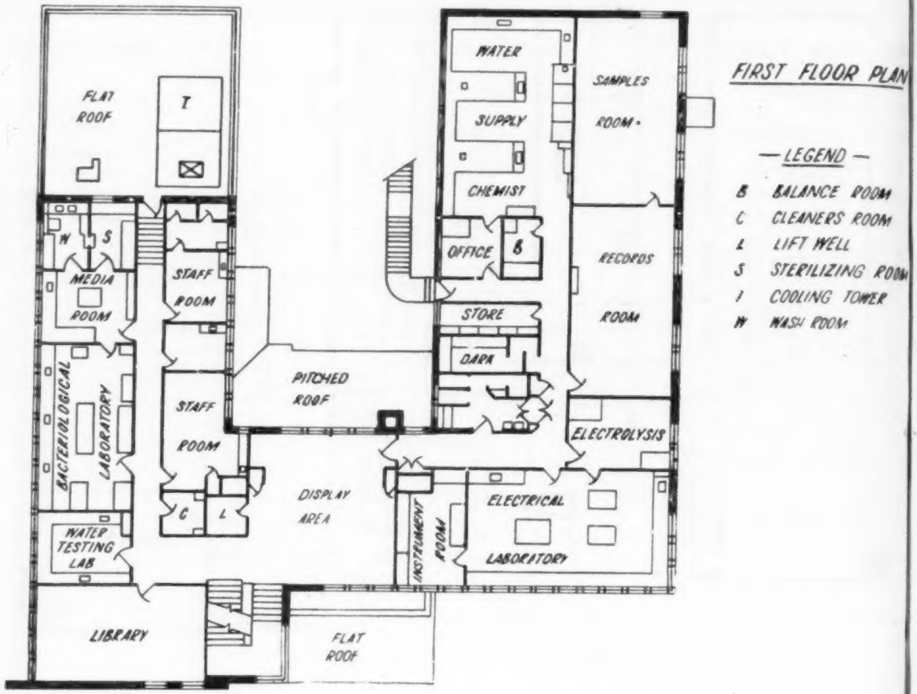

FIG. 3. Second-Floor Plan from Official Program

systems, and the results of the investigations will be made available to other sewerage authorities.

In addition, experimental work is being carried out to ascertain the possibility of obtaining a higher degree of efficiency in the methods of purifying the sewage at the Metropolitan Farm and to determine the effect thereon of any partial treatment to which the sewage might in future be subjected before its final treatment at the Farm.

Apart from the research work, the laboratory will be utilized for controlling the operation of the Board's sewage treatment plants at Braeside and Kew, for the investigation of particular trade waste problems, and for the supervision of sewage disposal at military camps in the metropolitan area. The information thus obtained will be of value to the Board in connection with the design and operation of future treatment works.

In the water supply bacteriological laboratory, examination of water samples will be carried out to insure the purity of the supply. The laboratory will also be available to examine the effect and efficiency of any treatment method should such action become necessary in the future.

Description of the Building

A U-shaped lay-out, which has been found to afford the maximum natural light for laboratory work, has been adopted. In the basement are housed the ventilating and heating plant and certain other auxiliary services, with ample strongroom space.

On the ground floor provision has been made for physical testing of soils and pipe-coating materials, for research in fluid mechanics, and for investigation of the chemical and bacteriological problems associated with sewage treatment and disposal.

On the second-floor will be accommodated the water supply chemical laboratories, an electrical laboratory for investigation into electrolysis and related corrosion phenomena; also a bacteriological laboratory for water examination and for investigation of corrosion attributed to soil bacteria.

The exterior of the building is faced with salmon bricks, the principal architectural feature being the L-shaped steel frame window which provides excellent lighting for the entrance hall and main staircase. The hall is panelled in bleached Queensland maple, and has cream terrazzo flooring to harmonize. The entrance doors are of stainless steel and polished plate glass, and carry the Board's crest.

At the head of the staircase, on the second floor, is an area with basket-weave parquetry flooring of mountain ash and jarrah.* This space is intended for the display of interesting and informative specimens. Nearby is a library for technical books and periodicals.

Continuous box-frame windows in timber provide good natural lighting for the laboratories and offices. Many benches have Queensland kauri † tops, stained black and acid-proofed, but in some instances jarrah and other materials have been adopted. Silver ash and hoop pine have been used for cupboards and drawers, which are built as removable units to facilitate access to the service ducts.

Linoleum has been chosen for the floor covering of the majority of the laboratories, but a granolithic or ironite finish has been adopted for wash, sterilizing, and tar rooms and for many of the basement rooms. To facilitate cleaning, all laboratories have tiled dadoes.

As far as possible Australian products have been used throughout, but in some instances, where materials have been in short supply, alternative materials have been employed.

Air-conditioning equipment has been provided in the basement to give adequate general ventilation, while individual fans have been fitted to fume cupboards and hoods. Inlet air for the main ventilating system is cleaned by oil filters and an air washer. The temperature of the air can be controlled by operating a precooler in summer or an air heater in winter. The precooler is connected to a cooling tower on the roof, while the air heater is fed from the boiler which supplies the hot water radiators.

After treatment, the air is delivered to the first and second floor rooms through ducts which are located above the false ceilings of the corridors. The air is exhausted under doors or through windows, some of which have the meeting-rails slotted to provide an outlet. Because pollution may occur in the laboratories, no attempt has been made to re-circulate the air.

The principal rooms in the basement have been fitted with exhaust registers, and the contaminated air is withdrawn through a separate duct system which discharges directly to the atmosphere. Fresh air enters the basement through hopper windows and wall vents.

* An Australian Eucalypt. The wood resembles mahogany.

† A tall timber tree. The wood is fine, white, straight-grained.

To examine the behavior of pipe-coating materials under conditions approximating summer and winter temperatures and to control the humidity of soil samples under test, three constant temperature rooms are located near the soil mechanics and pipe-coatings laboratories. All three rooms are heavily insulated by cork slabs.

The chemical laboratories are provided with special units for distillation and titration work, and acid effluents are neutralized before discharge to the sewers. All balance benches are fitted with anti-vibration devices. Fume cupboards have adjustable baffles mounted in front of the exhaust outlets, bench tops are formed with unglazed acid-resisting tiles, and the gas and water services are operated by remote control.

Ample refrigerators, incubators and sterilizers are available for bacteriological work, and special provision has been made for washing-up and for storage of glassware.

Compressed air and vacuum are provided in the majority of the laboratories, and gas and electricity are available throughout the building. A 40-volt battery in the basement supplies direct current for special purposes. An electrically-operated still delivers distilled water to the principal chemical laboratories.

As with other services, hot and cold water piping is concealed in ducts, and the branches are brought out through the tiled wall at the rear of the benches. Bib taps and swannecks are provided with tapered noses which can be unscrewed when not required. Where any possibility of contamination exists, the cold water supply is taken through a separate tank and ball valve, and, where water is used for cooling purposes, it is re-circulated to prevent excessive consumption.

A first aid room, with hot and cold water, gas and electricity, and a cabinet for sterilized dressings and medical accessories, is located in the south wing.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

ADMINISTRATION, PERSONNEL AND PUBLIC RELATIONS

Importance of Records Preservation. Munic. Finance Officers Assn. Tentative Rpt. Special Bul. Price 35¢. No doubt as to widespread interest developing in connection with care of public records. Some of this activity may be attributed to war. Devastating effects of bombing inspired numerous French and English authorities to contribute some valuable information and suggestions for handling of records in such emergencies. In U.S. agitation promptly started and, in some places, emergency precautions begun. Fortunately, conditions did not become sufficiently acute to cause much hasty or ill-considered action and time now available for more mature study and investigation. As no single system will meet needs of every state or municipality, prudent organization demands that consideration be given to size, pop., age and resources of each particular unit. Older cities and states have much more material already accumulated than some of newer ones. Many records of prime importance originate in counties, cities and other govtl. units and any complete program should include such units in organization plans. Record of what has been destroyed of much importance. Courts have, in most cases, ruled that secondary evidence admissible when "best" or "primary" evidence unattainable. Best proof that primary evidence not attainable is record of its destruction. It would seem to be much better to go into court with record showing destruction of some book than be forced to admit that "it's around somewhere, but we can't find it." Also better to destroy records and preserve authentic record of their destruction than to file them away in such manner that they cannot be located. No matter how important record may be, useless to preserve it unless it can be found when wanted. Emphasizes importance of orderly storage and adequate cataloging. To know that record exists and not be able to find it more disturbing than knowledge that it has been destroyed. Well-planned and definite system of storage should be established and strictly followed. Cataloging and indexing should be in such detail that record could be located regardless of variance or ambiguity of its title and contents. Important that some thought be given to future of records we are now making. For example, when known that certain record is to be kept permanently or for long period of time, it should be fashioned out of material selected for permanence and handled with care while in active use. ***What records of the various units of govt. should be permanently preserved and what should be preserved for certain periods of time after current use discontinued?*** What should be preserved permanently, of course, one of principal considerations and some variance of opinion concerning it. As kind of records, manner of keeping them and titles by which they are referred to vary in different localities, responsibility of final detn. must rest on local authorities. However, generally accepted that following factors merit major consideration—value of record for preserving information under general classification as follows: (1) historical, (2) statistical, (3) legal, (4) financial, and (5) unique or unusual.

When attempting to decide what should be destroyed, consideration should be given to statute of limitations, which will vary in different states. Especially true concerning records and other documents relating to contracts, notes, open accts., judgments, bonds, etc. Preservation of payrolls has become of increased importance because of deductions for social security, bond purchases, withholding taxes, pension and retirement deductions. Such data should, of course, be carried on records preserved permanently. There are certain other financial records not of permanent or historical value which should be kept at least for specified period during which some legal action may be taken to enforce claim. Retention of records and documents for period prescribed by law or charter is, of course, first consideration. **Retain Permanently:** (1) General ledgers, general journals and cash books. (2) Bond and interest ledgers and records of bonds and interest coupons destroyed. (3) Tax rolls and special assessment ledgers. (4) Property ledger. (5) Deeds and other title papers. (6) Records of tax liens, foreclosures and sales. (7) Records of securities owned or held in trust. (8) Records of employee earnings and payroll deductions. (9) Memoranda relating to outstanding warrants or checks not presented for payment, issue of duplicate checks, etc. (10) Reports which include general ledger balance sheets, trial balances, payroll summaries and anals. of operating figures for period longer than 1 yr. (11) Annual reports. (12) Auditors' reports. (13) Charts of accounts and manuals of instruction. **Retain Fifteen Years** (or permanently, at option of authorities): (1) Subsidiary ledgers, including revenue ledgers, appropriation expenditure ledgers, stores ledgers, miscellaneous accounts receivable ledgers, etc. (2) Cost and work ledgers and records. (3) Journal vouchers. (4) Books of original entry (other than general journals and cash books), including voucher, warrant and check registers, daily summaries of receipts and their distr., journal proof types from machine posting of subsidiary ledgers, etc. (5) Paid or cancelled warrants and checks. **Retain Seven Years:** (1) Duplicate receipts for taxes, special assessments, licenses, etc. (2) Bank deposit books and record stubs. (3) Paid or cancelled expenditure vouchers. (4) Contracts and leases. (5) Record of formal bids and advertising for bids on contracts and purchases where such procedure required. (6) Redeemed bonds and interest coupons (certificate of their destruction must be kept). (7) Bond and interest register (bond and interest ledger should be kept permanently). (8) Insurance policies, fidelity bonds, and records relating to claims. (9) Records of collateral pledged by depositories. (10) Memoranda relating to physical inventories. (11) Budget allotment documents. **Retain Three Years:** (1) Requisitions. (2) Purchase orders. (3) Shipping notices and bills of lading. (4) Records of material received. (5) Invoices. (6) Registers of requisitions. (7) Time tickets. (8) Assignments, attachments and garnishments. (9) Bank deposit slips and detailed records of items deposited. *Also suggested:* (1) No records should be destroyed until there has been independent post-audit covering period to which records pertain. (2) No records should be destroyed earlier than permitted by law. (3) Time given in this schedule should be figured from end of period covered by records; e.g., contracts should be retained for 7 yr. after expiration or cancellation, not merely 7 yr. from date contracts written. (4) Small sampling or selection of records not kept permanently should be taken for permament preservation before destroyed. (5) Correspondence should be kept for period prescribed for item to which it relates. Not to be assumed that foregoing schedule will meet conditions existing in all localities. Names or descriptions of records and necessary period of retention will vary and each local commission must make its own study and reach its own conclusions. Schedule offered as one of general application for municipalities. Growth of municipally-owned or controlled public utils. has added to importance of giving attention to this dept. of public service. Many records of importance accumulate in connection with management and operation of such plants and proper preservation becomes necessity. Those in charge of utils. best qualified to det. what is to be kept and for what period. In New York State the Public Service Com. has issued bulletin contg. directions for care of records which, together with other state laws and regulations, covers matter thoroughly. *Would it be advisable to store all records at place of origin or should some be transferred to central repository provided by state?* Practically all replies to this question favored storage of records at place of origin. This conclusion based on assumption that those seeking

information contained in records would naturally turn to place where same originated. Exception noted in places where central archives established under const. care of historical society or public library where provision made for safeguarding and proper cataloging and indexing more important records no longer subject to current demand. *Who or what group is best qualified to pass upon value of records considered for preservation?* This is definitely matter for admin. detn. guided by recommendations emanating from committee established in accordance with desire of admin. head of unit or units involved. Consideration should be given in formation of committee to assigning, as working members, key personnel of unit. Too often this primary management responsibility delegated and redelegated to point of ineffectiveness. Although desirable, not felt essential to have chief executive of each unit, div. or dept. personally engage in committee activities subsequent to establishment of basic policies. Essential, however, that vested authority be delegated to none other than personal representative of unit, div. or dept. concerned. Also, prior to establishment of any committee there must first be well-defined and clear-cut understanding of policy and objectives. Can never be over-emphasized that objectives of *space conservation, equip. conservation* and *personnel and material conservation* must at all times be acclaimed root from which all policies stem; and further, both formulation and execution of such policies should be balanced by controlled inclusion of extremists, legal advisors, and in some instances, historians and technicians engaged in scientific research.—*Ed.*

STREAM POLLUTION CONTROL

Ohio River Pollution Survey—Final Report. I, II, III. U.S. Pub. Health Service ('42). (Released Sept. '43). Presents sources, amts. and effects, on various water uses, of polg. material discharged into water-courses of 204,000-sq.mi. Ohio R. Basin and includes cost ests. for comprehensive poln. control measures. Survey included locating all important poln. sources and detg. amt. of polg. material discharged at each; measuring present effects of wastes on streams by phys., chem., bact., and biol. examns.; estg. effects of changes in stream flows and river conditions, also of possible future addnl. poln.; and detg. deg. of poln. abatement by treatment, low flow regulation or other methods appearing economically justified in view of present and prospective stream uses. This necessitated studies of water qual. requirements for various uses, of available techniques for correcting various types of poln. and cost, of disease outbreaks suspected of being water-borne, and of legal and admin. instruments and methods available for effecting poln. abatement. Besides supplying water to more than 7 million persons and for indus. processes, Ohio R. Basin streams used for sewage disposal by 8½ million, ¾ of sewage being untreated. Indus. wastes enter with B.O.D. equiv. to sewage from 10 million more. Poln. problems further complicated by effect of 1.8 million tons of acid per year from mines. Many domestic and indus. water supplies suffer from these polg. substances while intestinal disease outbreaks, apparently waterborne, occurred following periods of low stream flows. Recreation facilities damaged. Fish and other aquatic life affected detrimentally. Steamboats, barges, other river craft and structures, pumps, pipelines and condensers attacked by acid stream waters. Intensity of poln. problem not uniform, some streams receiving little waste, others much. Still others economically restorable to good san. condition. Survey results clearly show it neither practical nor desirable to establish uniform or permanent stds. of water qual. applicable to all streams in such extensive basin area. Yet, some deg. of treatment of all munic. sewage reasonable requirement in such highly urbanized and densely populated area even though harmful effects confined to possible odors, sludge deposits, floating sewage solids and scum in outfall vicinity. Low flow regulation by reservoirs important supplement to treatment and other corrective measures in sewage, indus. waste and mine acid abatement. Proposed and existing flood control reservoirs above Pittsburgh, under constr. on Mahoning, New Cumberland and Olentangy rivers outstanding in value for poln. control. In general, providing storage exclusively for poln. control unwarranted by benefits. If flow regu-

lated incidental to power or flood control, value for poln. abatement may economically justify project. Need and desire for poln. abatement in Ohio Basin. About half of sewage entering tributary streams treated except at Pittsburgh and Cincinnati. While negligible part treated from Ohio R. communities, this stream supplies water to more than 1,600,000 persons. Provision of sewage treatment facilities at Pittsburgh, Cincinnati and Louisville, and various measures for correcting mine acid poln., outstanding projects suggested in basin-wide abatement program. Salient features of main Ohio R. and 5 div. dists. of U.S. Engr. Dept. and their poln. problems cited. Financing necessary facilities always principal deterrent to poln. abatement. Effectiveness of grants-in-aid and low interest loans in accelerating work proved by 7-yr. experience. Doubtful whether such rapid progress continues without federal or state aid. Table summarizes cost ests. of waste treatment facilities including interceptors and treatment plants. Estd. capital cost of suggested program, including mine sealing, approx. $180,000,000 and annual charges for operation, interest and amortization approx. $18,500,000, based on avg. experience from '28 to '40. '42 costs would be considerably higher and future costs subject to change. Investigation authorized by Sec. 5, Rivers and Harbors Act, approved Aug. 26, '37; supervised by committee comprised of representative of Army Engr. Corps, U.S.P.H.S. and non-govt. expert. In presenting and discussing data collected, general section followed by uniform pattern summaries covering main Ohio R., minor tributaries and following individual tributary basins: Allegheny, Monongahela, Beaver, Muskingum, Hucking, Kanawha, Little Kanawha, Big Sandy, Guyandot, Scioto, Miami, Little Miami, Kentucky, Licking, Salt, Wabash, Cumberland, Green and Tennessee. Sources of poln., lab., and hydrometric data collected. Surveys made of 3700 municipalities and 1800 indus. plants. Information of poln. sources obtained by engrs. through 11 field stations maintd. in offices of state health depts. and TVA. *Supplement B—Organization and Methods of Lab. Studies.* Objectives: (1) To det. by systematic tests, sanitary qual. of waters in entire drainage basin, especially above and below poln. sources; (2) to obtain evidence of acid mine wastes and effects in mining sections; (3) to study measurable effects of mine sealing on acidity of streams receiving mine wastes, causes of tastes and odors, notably phenolic substances causing chlorophenol tastes commonly present, and presence of sludge deposits in pooled sections of main Ohio R.; and observe effects of sewage and indus. waste poln. on plankton and higher aquatic life in typical streams. Lab. operations conducted from fixed and floating base labs., supplemented by trailer labs., to survey area in 2 yr. Methods of lab. operations, sample collections, trailer labs., detns. and methods for chem. and bact. tests described and summarized. Of particular interest to lab. technician are instructions for routine bact., chem. and biol. examns. *Supplement C—Acid Mine Drainage Studies.* Acid drainage from coal mines affects streams throughout area dominating poln. picture in Pennsylvania and West Virginia. Studied basic theories of acid formation, possibilities and experience with remedial measures, particularly latter involving mine sealing and flow regulation, especially by multiple purpose use of flood-control and other purpose reservoirs. U.S. Bur. of Mines studies show acid control at mine practical at reasonable cost. Aggressive prosecution of suggested remedial program amply justified. Remedial measures imperative to insure future of principal streams in mining areas. *Supplement D—Industrial Waste Guides.* (Abstracted, Jour. A.W.W.A. **35**: 952 (July '43).) *Supplement E—Epidemiological Studies.* Field studies covered field epidemiological investigation of apparently water-borne disease outbreaks, field bact. studies of these outbreaks, lab. exptl. studies not definitely connected with disease outbreaks, and statistical study of mortality from diarrheal and enteric diseases throughout watershed. Studied in detail 2 gastro-enteritis outbreaks; mild afflictions characterized by nausea, vomiting, cramp and diarrhea, lasting but few days and practically with no mortality. Also studied outbreak of bacillary dysentery (Shiga), acute illnesses, extending over several weeks with considerable mortality. This contrasted sharply with those of mild, transitory gastro-enteritis. Evidence obtained that this type infectious and water-borne. Exptl. studies on human volunteers suggested possibly due to some hitherto unrecognized causal organisms perhaps undetectable by usual bact. tests for water potability. Statistical evidence obtained in 43 cities of watershed indicates filtration and chlorination of water supplies did not reduce diarrhea and enteritis death

rate to same extent as typhoid fever death rate in 5-yr. periods before and after installation of water purif. procedures. *Supplement F—Biological Studies.* Primary purpose to det. present biol. conditions for comparison with conditions after future changes due particularly to any remedial measures taken; and to det. destructive effect, particularly by present poln., on stream biol. communities and fish life as guide for corrective measures. Secondary purposes include detg. biol. and chem. conditions typifying different pollutional situations related humanly controllable factors, and combinations of these conditions allowable for given stream use. Biol. life closely related to stream sanitation. Change in magnitude or nature of poln. directly affects lower biol. forms, indirectly higher forms. Increased plankton content may cause tastes and odors, clog filters. Moderate poln. may promote aquatic life in otherwise barren stream, thus being beneficial to fish life. At same time, however, increased plankton growth may cause detrimental effect as tastes and odors. Sewage treatment removes portion of org. poln. load and stabilizes further portion, thus tending to improve aquatic life conditions and reduce damaging effect on water supply. Sewage or indus. waste effluents may exert immediate toxic effect on aquatic life or, more often, cause aerobic bacteria to multiply rapidly, thus sharply lowering D.O. concn. to asphyxial level for fishes or total depletion. D.O. level below 3 ppm., high B.O.D. and high coliform pop. evident in heavy org. poln. zone below source of poln. at distance detd. by temp., rate of flow and phys. character of stream. Biologically region dominated by bacteria-eating protozoa, colorless and chlorophyll-bearing flagellates requiring rich cultural medium. Fish represented mainly by coarser varieties such as carp and buffalo. Zone gradually blends through intermediate stage into fertile zone characterized by large variety and vol. of photosynthetic plankton and D.O. above 5 ppm. Fish varied and abundant. Further downstream plankton vol. diminished. This reduction in fish food directly affects fish pop., leaving game types dominant. Indus. waste effluents from coal mines, steel mills, paper and pulp mills, oil and gas refineries, sufficiently concnd., reduce aquatic life by direct toxic action or lowering pH to 4.5 or less. Fish flesh tainted and unpalatable. During spring high water, heavy and intermediate poln. zones scarce. With low flow conditions these areas distinct. Only one day thereof may exterminate fish pop.—*Ralph E. Noble.*

Sanitary Survey of Sewage Pollution of Santa Monica Bay. Elmer Belt. Western City **19:** 6: 17 (June '43). During past 10 yr., raw sewage reaching shore of Santa Monica Bay cities increased alarmingly. Mounting danger of epidemic disease and increasing filthiness of beaches from sewage grease recognized throughout period by Calif. State Bd. of Health. Pop. growth in this area extremely rapid. Within Los Angeles and immediately surrounding area is third greatest pop. concn. in U.S. Sewage from this multitude discharged into sea at Hyperion Beach. Great sewers overtaxed and north outfall sewer liable to burst from seams developed. Calif. State Bd. of Health made field investigation throughout '42 to det: amt. of sewage and condition of sewage plant; condition and operation of outfall; wind and weather behavior; air and ocean temps.; ocean currents and influencing factors; examn. of surf and pold. sand samples; isolate intestinal bacteria and record size and geog. distr. of beach crowds. Sampling points and findings described. Reports of investigation in progress. Monthly, thousands use beaches strewn with wave rows of sewage debris including grease-coated fecal pellets from $\frac{1}{16}''$ to $\frac{1}{4}''$ in diam. When squeezed, brown feces extrude from gray grease coating. To det. epidemiologically actual source of cases of typhoid, paratyphoid, dysentery and poliomyelitis in Los Angeles impractical. Survey revealed 3 life guards left jobs because of serious dysentery incapacitation of from 1 week to $1\frac{1}{2}$ mo. Onset followed shortly after rescue in pold. surf. One contracted paratyphoid B fever. Several frequent beach users gave histories of acute diarrhea after swimming in pold. surf. In them, no evidence of food poisoning. Sewage grease resembles sand in color. Visitors carefully avoid black tar but unwittingly walk and sit on wave rows of sewage grease. Reports from doctors in Santa Monica Bay cities and Los Angeles morbidity records indicate high deg. of danger from intestinal disease to swimmers in pold. surf. Doctors along bay report being unusually busy with dysentery cases; nos. proportional to no. of swimmers. Bacillary dysentery, paratyphoid fever and poliomyelitis incidence higher in Los Angeles than elsewhere in state according to pop. Hazard of sewage-borne poliomyelitis virus to

swimmers stressed. Should typhoid or other epidemics occur in Los Angeles, infecting organisms would reach beaches and serve as reinfecting pool for pop. of area.—*Ralph E. Noble.*

The Problem of Phosphorus in the Control of Pollution of Surface Waters. M. STANGENBERG. Arch. Hydrobiol. Plankt. (Ger.) **38:** 148 ('41); Gas u. Wasserfach (Ger.) **85:** 365 ('42). Author investigated content of dissolved and undissolved phosphates in domestic sewage and trade waste waters. Phosphates when introduced into a river influence growth of aquatic plants. This enrichment with phosphate of surface waters will prove harmful if water used for supply. Amt. of phosphate in waste waters can be controlled by suitable methods of treatment. Important to know content of phosphate in unpold. surface waters. Highest content of phosphate in combination found: in lakes, 1.0 mg.; in ponds, 2.0 mg.; and in rivers 1.5 mg./l.; corresponding figures for dissolved phosphate: 0.2 mg., 0.7 mg. and 0.7 mg./1. Expts. of author near Bialystok showed that, in spring and winter, river water poorer in phosphates than in summer, that river water, for most part, rich in phosphates in summer, and that water in lower course of river usually rich in phosphates. Necessary to decide what content of phosphates can be allowed in view of use to be made of water. If excessive amt. of phosphate discharged into stream, over-abundant growth of algae may develop which will rapidly decompose, causing lack of D.O. in water, production of hydrogen sulfide by fermentation and death of fish.—*W.P.R.*

Duties of the New Stream Pollution Control Board. THURMAN B. RICE. Monthly Bul. Ind. State Bd. Health **47:** 202 (Sept. '43). Anything that uses oxygen when placed in stream tends to cause stream poln. Types of wastes and their aggregate depletion of stream oxygen explained. State streams in bad condition prior to passage of '35 stream poln. bill; improved between '35 and '41 when many sewage disposal plants installed with fed. aid; then '41 legislature unintentionally repealed stream poln. act. In '43, law re-enacted and bipartisan Stream Poln. Control Bd. set up. New bd.'s duty to study needs for postwar program. Objectives: (1) remove disease hazard from streams and make drinkable for cities; (2) remove unsightliness and restore recreational use of streams and lakes; (3) find means of restoring ground and surface waters; and (4) prevent floods, soil erosion and corresponding loss of plant food elements.—*Ralph E. Noble.*

Sewage Disposal From Small Housing Projects. ANON. Calif.'s Health **1:** 24 (Aug. 31, '43). Numerous small fed. housing projects, each with special sewage disposal problem, threaten to lower san. stds. and promote stream poln. Difficulties encountered in providing water-flushed plumbing.—*Ralph E. Noble.*

Industrial Waste Disposal. F. W. MOHLMAN. Chem. & Met. Eng. **50:** 2: 127 (Feb. '43). Indus. wastes contg. up to 5% solids offer more opportunity of salvage than domestic sewage. Indus. waste disposal problem immense; estd. cost of treatment approx. 700 million dollars in Ohio R. Basin; pop. equiv. of wastes reaching river nearly 10 million; chem. and paper wastes predominate. Extensive survey of wastes in San. Dist. of Chicago made; at least 2 wk. spent at each of 300 plants. Total flow of wastes low—93 mgd. These contained 172 tons of suspended solids as compared to 400 tons per day from human sewage; pop. equiv. of 2.7 million large factor when added to human pop. of 3.96 million. Packing-house and stockyard wastes predominate with 26.3 mgd., 62.98 tons suspended solids and pop. equiv. of 734,000; food products, yeast and vinegar, malting and brewing almost as much with pop. equiv. of 659,200. Waste disposal of interest in connection with war economy. As example, TNT wastes—both acid or yellow and alk. or red. Intense colors which persist into high diln. may be troublesome to water works. All usual methods of treatment unsuccessful in removing this color (red liquor particularly objectionable). Chlorination greatly reduces color of acid waste; evapn. and diln. now only available remedies. Studies made on waters from Mo., Ohio, Ill., Susquehanna, Niagara and several other rivers, min. dilns. being specified. As result, in one case, evapn. plant (costing over $1,000,000) moved from one TNT plant where diln. of waste possible to another where evapn. only soln. War demands of 530 mil.gal. of alcohol per yr., 225 mil.gal. of which to come from fermentation processes carries with it enormous quant. of wastes. If all put into streams, would constitute load that would tax largest rivers. Salvage of phenol from ammonia-still wastes pro-

duced in byproduct coke plants assumed importance in war economy because phenol needed in mfr. of picric acid (trinitrophenol) and in mfr. of plastics. 2 phenol recovery systems used—benzol extraction process and "Koppers" vapor recirculation process. Disposal of acid waste pickle liquor from steel mills one of largest and toughest problems in disposal field. Urges establishment of divisions in indus. organizations to investigate waste disposal problems in logical steps, with reference to: (1) salvage of recoverable products; (2) detn. of relative importance of wastes from poln. standpoint; (3) study disposal methods available; (4) study river flows, B.O.D. re-aeration, oxygen balance, etc.; and (5) present data and meet san. authorities on tech. basis.—*Martin E. Flentje.*

Industrial Wastes in Wartime. F. W. Mohlman. Sew. Wks. J. **15:** 1164 ('43); cf. C.A. **37:** 2856. *TNT wastes* consist of (1) yellow first and second wash wastes having acidity of 7–25,000 ppm. and color of 20–40 when dild. 1:500 and (2) red sellite wastes having alky. of 860 and color of 570 at dilns. of 1:500. O-consumed values were 780 and 8600, resp., and B.O.D. values were zero. Public health hazard not involved and diln. of 1:10,000 will reduce color to 20–30. Fish survive and live at diln. of 1:800. A few plants without available diln. have installed evapn. and incineration of wastes. *Picrate wastes* also bright yellow acid wastes which in one particular plant handled in summer with diln. of 1:650 giving color of 63 to water. Fish survived 50 times this concn. *Smokeless powder wastes* contain 50 tons of H_2SO_4 and 13 tons of nitrate per 50 tons of powder produced and low B.O.D. due to some alc. Acidity neutralized with lime or limestone before discharge. *Shell casings.* From steel casing waste contains $FeSO_4$ and small amt. of Cu. Neutralization with lime sufficient at one plant. From Cu casings one plant in Chicago lost 277 lb. of Cu and 1744 lb. of oil per 24 hr. Not enough to affect large 400-mgd. West Side Chicago Plant. However, Cu detrimental to all biol. processes and particular care should always be taken to investigate wastes from Cu mills prior to installation of sewage works. *Airplane motor parts* and Mg parts pickled in chromic acid and HF baths, resp. These to be neutralized with waste NaOH soln. used to clean Mg castings. Addnl. NaOH to be added for neutralizing instead of lime which might become coated with CaF_2. *Oil refineries.* High octane gas production has increased refinery wastes. Some data indicate that A.P.I. separator operated at one-fourth its designed capac. gives effluent of 35 ppm. rather than claimed 15 ppm. EtOH production has doubled since '42 owing to its use in smokeless powder and synthetic rubber. Total pop. equiv. from this production will equal 27 million. Numerous evapn. plants installed and hoped that many more will be allocated. *Sulfite pulp wastes* being studied. Fermentation might produce 16.2 mil.gal. a yr. of alc. but would leave lignin which might be removed by Howard process. At Appleton, Wis., treatment of these wastes being studied with trickling filters, methane fermentation, contact aeration and ponding with stream-flow control. *Synthetic rubber.* In prepn. of butadiene there will be usual alc. and refinery wastes; however, from copolymer plants there will be spent soap solns. from polymerizing bath. Information on polg. effects of these wastes not yet available but estd. that 200 mil. lb. of soap or equiv. fatty acids will be used in this process during '44. Plants widely sepd. and some on large rivers. *Dehydrated food wastes* not expected to constitute serious problem, except perhaps in some isolated cases. *Stockyard's wastes* at Chicago have shown increase of 500,000 pop. equiv. since '40 and losses from corn products industry have increased over 100% since '36 while grind has only increased 26%. *Pickle liquor wastes* from iron and steel industry have more than doubled since '38. Fat-saving program of WPB showing marked effect on recovery of fats. In discussion of paper reported that Cr^{+++} tolerated by digestion and trickling filter plants as high as 10 ppm. in sewage. Cu^{++} very toxic but so far has not caused major troubles because of low concns. *S* dye wastes best decolorized by chlorination at sewage treatment plant. Fiber wastes should be screened at source, but continued inspection necessary to keep screens in use.—*C.A.*

Surveys of Liquid Wastes From Munitions Manufacturing. Russell S. Smith & W. W. Walker. Pub. Health Rpts. **58:** 1365 (Sept. 10, '43). I. *Trinitrotoluene (TNT) Wastes:* Waste surveys made at 3 plants mfg. trinitrotoluene. Waste generally clear, highly colored, strongly acid and high percentage of solids volatile. Has noticeable chem. odor and taste, best described as "acid." Appar-

ently very stable. Does not readily decompose in stream, nor does it seem to combine with other materials found in normal stream used for water supply to intensify taste and odor troubles. Color apparently cannot be removed by means of coagulation methods normally used in water treatment and can only be reduced or elimd. by means of adequate diln. Waste in concn. of ½% in filtered and chlorinated Ohio R. water gave no odor and barely perceptible "acid" taste. Very noticeable increase in color, however. Waste apparently nontoxic to warm-blooded animals. II. *Smokeless Powder Wastes:* Waste surveys made at 3 smokeless powd. plants. Such type plants discharge large vol. of liq. strongly acid waste high in sulfates and nitrate nitrogen. Except for this acidity, waste would have less deleterious effect on receiving stream than same vol. of domestic sewage after primary treatment. *Ibid.* **58:** 1393 (Sept. 17, '43). III. *Small Arms Ammunition:* Indus. waste surveys made at 3 large plants mfg. small arms ammunition, .30 and .50 caliber cartridges. Although very similar and approx. same size, plants showed marked differences in waste flows, due to differences in proportion of caliber size mfd. and to unknown causes. Greater waste flow and larger actual amts. of waste products per 100,000 rounds of finished ammunition from .50 than from .30 caliber cartridges. On avg., however, per 100,000 rounds of mixed ammunition, expect 36,000 gal. contg. about 100 lb. of grease, 12 lb. of copper, 95 lb. of volatile suspended solids and a 5-day B.O.D. pop. equiv. of 300 people. Plant treating this waste by grease flotation and chem. ppt. described. Operating results tabulated. IV. *Tetryl Wastes:* Except for acidity, waste apparently would not cause serious trouble in receiving stream. In common with wastes from all types of explosive plants, however, high in nitrates which might promote increased algal growths in receiving stream, causing tastes and odors in water supply and short filter runs in treatment plant. If discharged into sizeable river and adequately mixed, waste apparently should not require predischarge treatment. V. *Nitroglycerine Wastes:* Except for intermittent acidity, waste from nitroglycerine mfr. would not cause serious difficulty in receiving stream. Org. matter low; 5-day B.O.D. generally lower than that of effluent from munic. sewage plant with secondary treatment. Sulfates and soap hardness may be slightly high but should not cause serious difficulty. NO_3 nitrogen might increase algal growth but concn. less than that from smokeless powd. plant. Presumably acid neutralization only treatment required. Would be greatly aided by adequate balancing pond ahead of neutralization plant to prevent sudden strong acid waste flushes. In many cases such pond, sufficiently large, would be ample treatment.—*Ralph E. Noble.*

TNT Wastes. STUART SCHOTT, C. C. RUCHHOFT & STEPHEN MEGREGIAN. Ind. & Eng. Chem. **35:** 1122 (Oct. '43). Wastes from TNT plants characterized by low pH, high color, relatively high total solids, sulfates and oxygen consumed values, and distinctive odor. No 5-day B.O.D. observed, thereby indicating interference with biochem. activity in seeded samples. Activated sludge process hampered by concns. above 5%, and sprinkling filters by more than 10% concns. Neutralization, chem. pptn., fractionation, solvent extraction, ozonation and electrolytic reduction unpromising. Activated carbon effective but at prohibitive cost. Bromination reduced color more effectively than did chlorination but choice between these treatments depends on economic factors.—*A. A. Hirsch.*

War Production Board—Office of War Utilities

Utilities Order U–1 Revisions of August 31, 1944

UTILITIES Order U–1 and related subsidiary orders were amended on August 31. It has been customary to publish these orders as they are issued so that members of the Association could refer to them when necessary in the columns of the JOURNAL.

The orders appearing here are published even though the publication follows the release of a definite statement by Acting Chairman J. A. Krug of W.P.B., which outlined policy to be followed after the capitulation of Germany. It is not assumed at the time of writing that the capitulation will occur before the issuance of the JOURNAL. However, if it does, the JOURNAL's editor will consider Victory superlative compensation for wasted JOURNAL space. In any event it will leave JOURNAL readers with a printed record on hand.

Supplementary Utilities Orders U–1–a, U–1–c, and U–1–i as amended Aug. 31, 1944, are not reproduced at this time because they relate to classes of service that the water works industry is not called upon to render.

Krug's Statement

Following a meeting of the War Production Board on September 5th it was announced by J. A. Krug, Acting Chairman, that the Army, Navy, and major war agencies had unanimously agreed on a program designed to provide the utmost stimulus to reconversion when Germany is defeated, while at the same time protecting production necessary for the Japanese war.

Acting upon findings that there will be a reduction of about 40 per cent of war production within three months after the defeat of Germany, resulting in the freeing of over 4,000,000 workers, the Board decided to:

1. Remove almost all controls over materials immediately upon the defeat of Germany except those that are absolutely necessary to assure the reduced measure of war production necessary to beat Japan. This means that all manufacturers can use any plant and any materials that are not needed for military production for any civilian production.

2. The War Production Board and other Government agencies will do everything within their powers to assist and encourage industry in resuming civilian production and maintaining employment through the "know-how" of its industry divisions and industry and labor advisory committees.

3. The Board will maintain its organization and powers so as not to relinquish authority until it is certain that the war production program is adequate for victory over Japan.

The purpose of the decision, arrived at by the Board after a sweeping resurvey of the military and production

situation, is two-fold. First, it will assure full military production until final victory over Japan. Second, it will free civilian enterprise to the utmost.

Industry is to be allowed, in its own way, according to the availability of markets, men, materials and plants, to do the swiftest and most effective job possible of restoring production, making whatever people want and affording maximum employment. The plan is simple in outline. Detailed procedures for putting it into effect will be developed promptly. The plan provides as follows:

There will be only one preference rating, in addition to the present emergency AAA rating, and this rating will be reserved exclusively for military programs during the war against Japan. All other production will be unrated. Manufacturers will be permitted to accept unrated orders but they will be obliged to fill rated military orders ahead of all other business.

After Germany's collapse no programming of civilian production will be necessary. The information which the War Production Board has on the available supplies of materials, components, facilities, and manpower indicates that maximum civilian output can be achieved without detailed priorities regulation from Washington. The War Production Board will retain its Industry Divisions and its Industry Division Requirements Committees whose job will be to make certain that no one is permitted to procure an unreasonable amount of any material or product, that needed materials and components are made available to top essential civilian activities such as transportation, utilities, and fuel, and that small business is given an equal opportunity to secure materials and supplies.

A very few allocation orders will be continued for materials that remain tight, such as lumber, textiles and certain chemicals. For example, it will be necessary to continue strict controls of the use of lumber, particularly for major construction projects.

The Controlled Materials Plan for allocating steel and copper will be continued only for the quarter in which hostilities in Europe cease.

Paul V. McNutt, Chairman, War Manpower Commission, was present at the W.P.B. meeting and endorsed the program outlined. He indicated that the W.M.C. will shortly announce a program for manpower after Germany's collapse, designed to dovetail with the W.P.B. procedure.

Krug said, in deciding upon immediate and drastic elimination of production controls, that the W.P.B. is planning on keeping its steering gear and brakes in good condition. During the past three years the W.P.B. industry divisions have developed methods that have been notably successful in dealing quickly and effectively with industrial problems. This "know-how" will be kept available for immediate use as needed. Also available will be the Industry Advisory Committees, the authority to allocate materials and to schedule production of components when supply becomes critical. If troubles should occur in military production or civilian output, W.P.B. will be able to handle them on a spot basis. With the removal of controls on production, industrial, civic and labor leaders in every community will be called upon to use their ingenuity and resourcefulness to overcome the home front difficulties on the way back.

Administrative Letter to All Utilities—August 31, 1944

Utilities Order U-1 [issued Feb. 24, 1943] and the Supplementary Orders in the U-1 series have been amended, effective Aug. 31, 1944, for the principal purpose of giving blanket authorization to certain types of plant additions, including consumer connections, which are now generally being approved when requested on WPB-2774 applications.

In addition, the requirement that certain purchases must be cleared through the Regional Utility Engineers has been revoked and the quantitative restrictions on deliveries in paragraph (e) (1) and Schedule B have been removed.

A description of the more important changes is given below.

Changes in Order U-1

The net dollar value for material included in a "minor plant addition" has been increased from $1,500 to $10,000. It will no longer be necessary to file applications for plant additions (except extensions of lines to serve new consumers not authorized by a supplementary order) if the net dollar value for material is $10,000 or less, and the installation is essential to maintain service at minimum standards as outlined in paragraph (i).

A change in the ratings which may be used to purchase water, gas, and electric meters appears in paragraph (b). The use of the preference rating AA-1 to purchase meters is limited to cases where they are needed to replace defective meters in service, or to replenish the minimum inventory of meters required to be held by a utility for meter replacements. The preference rating AA-3 must be used when the meters are required for other purposes, such as for new customer installations. This rating pattern is identical with that being used in the case of the transmission and distribution class of material.

In this connection Schedule A in the electric utilities material classes has been revised to state explicitly the kinds of material for which the AA-1 and AA-3 ratings assigned in paragraph (b) may be used. In the case of electric power producers Order U-1 assigns a preference rating of AA-1 for all purchases of material for generating plant, switching and substation material and wood poles and crossarms. The preference rating AA-3 should be used for meters and transmission and distribution material except in the case of requirements for actual or imminent breakdown.

Major changes have been made in paragraph (e). Paragraph (e) (1) which restricted scheduled deliveries on a calendar quarterly quota basis has been revoked, and the related Schedule B which stipulated the calendar quarterly quotas for scheduled deliveries has been deleted.

A new subparagraph (3) has been added to paragraph (e), which prohibits the purchase of any item of material if the item or a practical substitute therefor is available in the utility's inventory in excess of minimum requirements.

Paragraph (f) (1), which established special provisions for inventory and deliveries as to utilities whose inventories did not exceed $10,000 in value, has been modified. Under the new provisions of this paragraph utilities whose inventory is $25,000 or less need not maintain their inventory accounts by materials "classes." However, all purchases by utilities whose total inventories as defined in paragraph (a) (11), are less than $25,000 have been made subject to the restrictions of paragraph (g) which states that items of material must not be ordered in excess of a ninety days' supply.

A new subparagraph (i) (5) has been added concerning the alterations or construction of buildings by utilities. This change has been made in anticipation of a forthcoming amendment of Limitation Order L-41 which will exempt the construction and alteration of buildings by producers as defined in U-1 from the controls of Order L-41.

Paragraph (i) (5) of Order U–1 requires that utilities altering or constructing buildings must conform to the provisions of paragraph (e) and Appendix I of Schedule A to CMP Reg. 6 whenever the cost of materials and labor for any such construction or alteration exceeds \$800. Paragraph (e) of Schedule A to CMP Reg. 6 provides wartime specifications for the structural design of buildings where more than five tons of structural or reinforcing steel are involved, or where any stress grade of lumber is to be used. Appendix I of that Schedule limits the use of certain materials in building construction. Under this U–1 procedure, utilities will apply on WPB–2774 whenever the cost of the materials for any building construction or alteration exceeds \$10,000, or if the utility wishes either to use a structural design or a material prohibited by Schedule A to CMP Reg. 6.

A new exception (f) (7) to the short item provision states that, notwithstanding any of the restrictions of paragraph (g), pipe, except copper or brass pipe, may be ordered in minimum carload quantities. In addition, any material may be ordered in a minimum procurable commercial quantity. For example, if a utility requires a small amount of a special type of material not obtainable in a manufacturer's or dealer's stock, a minimum mill run may be ordered even though such a quantity would exceed ninety days' requirements.

Paragraph (g) has been substantially changed by the deletion of subparagraph (2) in order to relieve utilities of the necessity for keeping continuous records of excess inventories, and of reporting them. This change, together with the deletion of paragraph (l) (1), also removes the provision that a utility must offer for sale or sell any material in excess inventory. It should be noted, however, that the order continues to require the sale of material to another utility for the repair of an actual breakdown.

Sales of material and equipment by utilities may be made according to the provisions of paragraph (k) and such sales are entirely independent of Pri. Reg. 13. The rules applicable to sales of material contained in paragraph (k) have been simplified. Sales between utilities of any material may be made without a preference rating or an allotment number. Sales of *used* equipment by utilities to non-utility purchasers may be made without a preference rating or allotment number, subject however to the provisions of applicable orders and regulations of the War Production Board which govern the sale of certain items such as used generating equipment, used construction machinery and industrial power trucks. However, any utility which chooses to do so may follow the provisions of Pri. Reg. 13 and make any sale permitted under Pri. Reg. 13.

The provisions of the order which required the purchase of certain items of material to be cleared through the Regional Utilities Engineers have been discontinued. The redistribution of materials in excess inventories brought about by the inventory redistribution plan of Order U–1 has helped to reduce the load on manufacturers and to minimize the demand for materials at a time when they were in critically short supply. The amount and kind of material remaining in excess inventory is such that it is no longer readily redistributable and the results being obtained through the inventory redistribution procedures are not commensurate with the efforts required. Accordingly, paragraph (m) and Schedule D of the Order have been deleted as well as the other provision of the order which related to accounting for and redistribution of surplus utilities materials. Although the compulsory redistribution provisions of the order are deleted it is expected that utilities will continue the distribution of excess materials on a voluntary basis.

Paragraph (s) has been amended to conform to the change which eliminate

quotas for scheduled deliveries. Specific quotas for scheduled deliveries previously established for any producer are revoked.

A new paragraph (t) permits producers to use the ratings and allotment number assigned in paragraphs (b) and (c) to obtain material for construction approved on WPB–2774 applications prior to the date of this amendment in cases where the net material cost is between $1,500 and $10,000. Utilities may also segregate material for such construction from U–1 inventory.

Changes in the Supplementary Orders

The increase in the dollar value for minor plant additions to $10,000 has been reflected in supplementary orders U–1–a, U–1–d, and U–1–f. In the case of Order U–1–c the restriction limiting the length of a continuous extension built in any calendar quarter to 5,000 feet effectively limits the amount of material which may be installed, and the dollar value limitation has therefore been deleted. A $1,500 limitation has been retained in U–1–g and U–1–i.

A further change in all of the supplementary orders in the U–1 series is the revocation of the restriction which provided that no producer might undertake an extension to serve a consumer if another producer could render the service with less use of critical material. The principal reason for abandoning this restriction is that it has been found difficult in many cases for producers to determine if another producer would use less material in rendering a given service, and the time and effort required for utilities to make such determinations does not appear to be consistent with the small amount of additional material that might be involved. It is emphasized, however, that the restrictions against an extension of service which duplicates an existing service or constitutes a standby service are continued.

In considering WPB–2774 applications for service extensions to consumers in excess of the limits stated in the Supplementary Orders, approvals will be given in the future without regard to whether or not the applicant can render service with less materials than any other producer. An answer in reply to Item 5, in Section II of Form WPB–2774, need no longer be given in filing such applications and if it is given, it will be disregarded in processing the application. However, where competing applications are presented for authority to provide the same service, the War Production Board will ordinarily give approval to the applicant who requires the least material to render service.

Other changes in the supplementary orders are outlined below.

Order U–1–a.—No changes except those described above.

Order U–1–c.—A change in paragraph (a) (5) (i) permits the use of conductor of No. 4 copper equivalent conductivity for secondary lines instead of the No. 6 conductivity conductor formerly specified. A new provision requires, for the purpose of economy in the use of small transformers, that extensions of secondary up to 750 feet in length must be used in preference to the installation of individual transformers, unless the resulting voltage drop over long secondary lines would be excessive.

Order U–1–d and Housing Utilities Standards.—In Order U–1–d, extensions of service to commercial consumers are now restricted to 1,000 feet in length.

The definitions of "domestic," "industrial," and "commercial" consumers which appear in Order U–1–f have been included in Order U–1–d.

The wording of paragraph (b) now permits extensions of utilities facilities to farm dwellings which are being built or remodeled under L–41 authorizations provided that the Housing Utilities Standards are complied with.

The Housing Utilities Standards have been revised in the following respects:

1. The length of pipe per dwelling unit permitted for extensions of water and gas facilities has been increased to 250 feet

for single family detached structures and to 200 feet for multiple family structures.

2. An extension up to 1,000 feet in length is permitted in cases where the builder's application is for the construction or remodeling of one to three structures.

3. The minimum permissible spacing between street lights has been reduced from 500 to 350 feet.

Order U–1–e.—This order has been revoked. Extensions of service to Victory gardens may be made under Order U–1–f provided that no more than 1,000 feet of pipe is used for each extension.

Order U–1–f.—Former paragraph (b) (5), now paragraph (b) (4), has been reworded to clarify the interpretation of the rule relating to "duplications" of service. The fact that an adequate electric

Explanatory Chart, Supplementary Orders in the U-1 Series*

Type of consumer	Applicable supplementary order	Principal limitations
Armed services	U-1-a	Limited to $10,000 for material.
Agricultural (electric farm equipment)	U-1-c	100 feet of extension per animal unit. Certification by County Agricultural Conservation Committee. Length of continuous extension, regardless of number of consumers, limited to 5,000 feet per calendar quarter.
Domestic (including farm dwellings)	U-1-d	Where construction by or for consumer is involved and builder files application under L-41. Housing Utilities Standards. Form 3348 is filed with builder's application.
	U-1-f	Where no application is being filed under L-41. Utilities Construction Standards.
Commercial and industrial	U-1-d	Where construction by or for consumer is involved and builder files application under L-41. Form 3348 is filed with builder's application. Commercial consumers limited to 1,000 foot service while industrial consumers limited only to $10,000 net material cost.
	U-1-f	Where no application is filed by consumer under L-41. Consumer listed on Schedules I or II of CMP Regulation 5 or is otherwise listed in U-1-f. Commercial consumers limited to 1,000 foot service while industrial consumers limited only to $10,000 net material cost.
Temporary	U-1-g	Ninety days' use of service. Limited to $1,500 material cost.
Irrigation	U-1-i	Maximum material cost $1,500. Minimum of 5 acres to be irrigated and not less than 25 gallons per minute pumped. Certification by County Agricultural Conservation Committee.
Street lights	U-1-f	No extension exceeding 1,000 feet and lights limited to those necessary for public safety. No new transformer installation.

* If proposed extension exceeds the limitations of the applicable supplementary order, utility may request authority to proceed with the construction by filing Form WPB-2774 with the Office of War Utilities, War Production Board, Washington, D. C.

service for cooking or water heating is already installed in a dwelling was not intended to prevent the installation of gas facilities, nor does the existence of a gas service adequate for cooking and water heating purposes preclude the extension of "three wire" electric service to the same customer.

The permissible length of service to domestic and commercial consumers has been increased to 1,000 feet. In the case of electric extensions to domestic consumers, however, no additional transformer installation may be made unless the electric service is for the operation of an electric range, refrigerator, or washing machine in the consumer's possession.

The wording of the restrictions on the installation of copper and copper base alloy pipe or tubing by water and gas producers has been changed to conform with Conservation Order M–9–c–4, and the inference that the use of this material by plumbers is controlled by Order U–1–f has been eliminated. The provision that the maximum permissible length of this material should not exceed that required to run from the main to the consumer's curb stop or property line has also been deleted. In this connection, the Copper Division has requested this office to make it clear that this change in no way implies that copper tubing will soon become available for purchase. On the contrary, the shortage in this material continues to be acute, and no new supplies are expected to be available for some time to come. It is therefore expected that utilities will adopt strict conservation methods of their own, to make their present stocks last as long as possible.

Orders U–1–g and U–1–i.—These orders have not been materially changed, and the $1,500 limit has been retained.

Order U–1–h.—This order has been revoked, since the limiting dollar value of Order U–1–d has been increased to $10,000 and it therefore covers the area formerly covered by Order U–1–h.

Direction 2 to Order U–1.—Paragraph (e) of this direction which dealt with clearance of orders through Regional Utility Engineers has been revoked in view of the revocation of paragraph (m) of Order U–1 described above.

Other minor changes have been made for the purpose of clarification.

Very truly yours,

(Signed) EDWARD FALCK,
Director,
Office of War Utilities

Administrative Letter to All Water Utilities—September 1, 1944

NEW STANDARDS IN PROCESSING APPLICATIONS FOR WATER FACILITIES

The Office of War Utilities has adopted new standards for screening applications from water utilities. These new standards, which are effective at once, are designed to improve reliability and quality of water service which may have been impaired during the war period.

Since the establishment of the priorities system in 1941, all water supply projects have been rigorously screened. Generally speaking, only such projects as were needed to avert a serious shortage have been approved; additions and betterments have been postponed; and engineering design and specifications have been limited by the objective of the utmost conservation of material. These policies were made necessary by the wartime shortages of materials, manufacturing space and manpower. At the present time, conditions affecting the supply of raw materials and the availability of manufacturing space are such as to permit a moderate expansion of water utility facilities without interference with direct war production.

While the changes in the overall situation permit some increase in utility con-

struction, important shortages continue in the supply of steel, lumber, selected components, and manpower. Accordingly, it will continue to be necessary for utilities to apply to the War Production Board for individual project authorizations, and such authorizations will continue to be based upon standards of relative urgency and need.

The following statements as to policy are intended to aid water utility operators in submitting applications:

(1) *A new or additional supply of water.* Favorable consideration to applications will be given if estimated future requirements exceed firm capacity and if the proposed facilities provide a reasonable increment consistent with sound engineering and economics.

(2) *New or additional treatment facilities.* Favorable consideration will be given if the raw water is of uncertain or poor quality and if the operating rates have been in excess of standard water works practice. The new facilities should permit operation at rates consistent with safe operation.

New facilities where needed for applying chemicals to water for treatment or disinfection will be approved; and where continuity of application is essential for public health protection, favorable consideration will be given to applications for reserve units.

(3) *Pumping equipment.* Favorable consideration will be given if the equipment is necessary to maintain adequate service at times of maximum demands and to provide a reserve consistent with good water works operating practice, commensurate with the size and type of plant and equipment used.

(4) *Transmission facilities* needed in the development of new or additional supplies to correct deficiencies in present transmission capacity will be given favorable consideration, provided their construction involves a minimum practical use of critical materials. *Extensions or betterments in distribution systems* required to correct present deficiencies in service to consumers or to improve fire protection will be given favorable consideration. Pipe sizes appropriate to general system planning will be approved, provided a minimum of critical material is used.

(5) *Elevated storage tanks.* The heavy demands for steel, particularly flat rolled products, have made it necessary since the beginning of the war to defer the construction of elevated steel storage tanks. A limited number of elevated storage tanks will be approved in the future. Very few can be approved in the fourth quarter of 1944, but a larger amount of tank steel should be available for fabrication and erection in the first quarter of 1945 and thereafter.

Water utilities which have need for new facilities along the lines above indicated are requested to submit their applications promptly. Because this moderate expansion program is strictly limited by available quantities of materials and manpower, only the more urgent projects should be selected by each utility out of its backlog of deferred construction. For utilities situated in tight labor areas, such as the Group 1 and 2 areas designated by the War Manpower Commission, only such projects should be submitted as can be carried out by utilities' existing labor force, or, in exceptional cases, where only a small number of additional construction workers is required.

Very truly yours,
(signed) EDWARD FALCK
Director
Office of War Utilities

UTILITIES ORDER U-1 AS AMENDED AUGUST 31, 1944[1]

PART 4500—POWER, WATER, GAS, AND CENTRAL STEAM HEAT

[Utilities Order U-1 as Amended Aug. 31, 1944]

UTILITIES

PART I—DEFINITIONS

(a) Definitions.

PART II—HOW TO OBTAIN MATERIAL

(b) Preference ratings.
(c) CMP allotment number.
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(h) Restrictions on use of material for maintenance and repair.
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PART V—SELLING MATERIAL

(k) Sales of material.
(l) Refusal to sell to other producers.

PART VI—INVENTORY REDISTRIBUTION

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PART VII—GENERAL PROVISIONS

(n) Appeals.
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PART VIII—SCHEDULES

Schedule A, Material Classes.
Schedule B, Delivery Quotas.
Schedule C, Limits on Practical Working Minimum Inventory.
Schedule D, Items To Be Cleared Through Regional Utility Engineers.

Part I—Definitions

§ 4500.1 *Utilities Order U-1*—(a) *Definitions.* (1) "Producer" means any individual, partnership, association, corporation, governmental corporation or agency, or any organized group of persons, whether incorporated or not, located in the United States, its territories, or possessions, supplying, or having facilities built for supplying, directly or indirectly for general use by the public, one or more of the following services:

(i) Electric power,

(ii) Gas, natural or manufactured, exclusive of the production and transmission of natural gas up to the point of its entry into gas transmission lines from field gathering lines,

(iii) Water, other than exclusively for irrigation purposes,

(iv) Central steam heating, or

(v) Any of the foregoing services but not for general use by the public, if a specific direction from the War Production Board entitles such person or agency to apply the ratings herein assigned. Application for such a specific direction should be made by letter to the War Production Board, Washington 25, D. C., Ref.: U-1.

(2) "Material" means any commodity, equipment, accessory, part, assembly or product of any kind.

(3) "Controlled materials" means controlled materials as defined in Schedule I of CMP Regulation 1.

[1] Utilities Order U-1 as amended Jan. 22, 1944, appeared in the JOURNAL, **36**: 238; as amended Sept. 24, 1943, in the JOURNAL, **35**: 1375. In the text of U-1 herein a number of paragraphs have been deleted. Reference to the previously published orders will show exactly what each deleted paragraph contained.

(4) "Maintenance" means the upkeep of a producer's property and equipment in sound working condition. It does not include any plant addition.

(5) "Repair" means the restoration of a producer's property and equipment to sound working condition after wear and tear damage, destruction of parts, or the like have made such property or equipment unfit or unsafe for service. It does not include any plant addition.

(6) "Plant addition" means the construction or installation of new facilities or the replacement of existing facilities with facilities of greater capacity.

(7) "Minor plant addition" means a plant addition having a net material cost of not more than $10,000. No job or project may be subdivided to come within this limit.

(8) "Major plant addition" means a plant addition having a net material cost of more than $10,000.

(9) "Net material cost" means the cost of material incorporated in plant less the cost of material removed from plant, priced in accordance with the producer's regular accounting practice.

(10) "Operating supplies" means material, other than fuel, which is used or consumed in the course of a producer's operations, except in maintenance, repair and plant additions.

(11) "Inventory" means all material in the producer's possession, without regard to its accounting classification, excluding, however, (i) material incorporated in plant, (ii) appliances and merchandising supplies, (iii) fuel, (iv) water purification and treatment material except equipment, (v) gas chemical material, (vi) material segregated for use in approved major plant additions, and (vii) scrap.

(12) "Class" means any one of those categories of material established as a basis for classification of inventory in Schedule A of this order.

Part II—How To Obtain Material

(b) *Preference ratings.* (1) A preference rating of AA–1 is hereby assigned to orders to be placed by a producer for material (other than controlled materials) in every class except (i) the transmission and distribution class and (ii) the meter class, for use in maintenance and repair, as operating supplies, and for minor plant additions.

(2) A preference rating of AA–1 is hereby assigned to orders to be placed by a producer for material (other than controlled materials) in (i) the transmission and distribution class and (ii) the meter class, for use in the repair of an actual or imminent breakdown.

(3) A preference rating of AA–3 is hereby assigned to orders to be placed by a producer for material (other than controlled materials) in (i) the transmission and distribution class and (ii) the meter class, for use in maintenance and repair, as operating supplies, and for minor plant additions, except where an AA–1 rating is assigned in paragraph (b) (2) above.

(4) Material obtained with the AA–1 rating may be used for purposes which are assigned lower ratings, but it may be replaced in inventory only by applying the lower rating to an equivalent dollar value of material in the same class. Material obtained with the AA–3 rating may be used for purposes which are assigned the AA–1 rating and may be replaced in inventory with either the AA–1 rating or an authorized AA–3 rating. The provisions of this paragraph (b) (4) supersede those of § 944.11, paragraph (a), of Priorities Regulation 1.

(5) Preference ratings for major plant additions may be obtained by filing an application on Form WPB–2774.

(c) *CMP allotment number.* (1) The abbreviated CMP allotment number U–9 is hereby assigned to orders to be placed by a producer for controlled materials

for use in maintenance and repair, as operating supplies and for minor plant additions. Allotments of material for major plant additions may be obtained by filing an application on Form WPB-2774.

(2) An order for controlled materials for use in maintenance and repair, as operating supplies and for minor plant additions bearing the abbreviated CMP allotment number U-9 and the certification required by paragraph (d) of this order shall be deemed an authorized controlled materials order. This abbreviated CMP allotment number shall constitute an "allotment number or symbol" for the purpose of CMP Regulation 3.

(d) *Certification.* The ratings assigned by subparagraphs (b) (1), (2) and (3) of this order and the abbreviated CMP allotment number U-9 may be applied by a producer only by the use of a certification in substantially the following form unless an order of the War Production Board affecting a particular item of material requires some other form of certification:

Preference Rating ......, Abbreviated CMP Allotment Number U-9. The undersigned producer certifies subject to the penalties of Section 35 (A) of the United States Criminal Code, to the seller and to the War Production Board, that, to the best of his knowledge and belief, the undersigned is authorized under applicable War Production Board regulations or orders to place this delivery order, to receive, for utility uses under Utilities Order U-1, the material ordered, and to use the preference ratings or allotment numbers which the undersigned has placed on this order.

The certifications set forth in Priorities Regulation 3 and CMP Regulations 1 and 5 may not be used but the standard form of certification provided in Priorities Regulation 7 is permissible if the producer adds a statement saying that material ordered is for utility uses under Utilities Order U-1.

Part III—Restrictions on Ordering Material

(e) *Scheduling deliveries.* Except as permitted by paragraphs (f) and (g) below, no producer shall schedule for delivery to it in any calendar quarter any material to be used for maintenance and repair, as operating supplies, or for minor plant additions, unless both of the following conditions are satisfied:

(1) [Deleted Aug. 31, 1944.]

(2) The producer does not have reason to believe that its inventory of material in the same class is or will, by virtue of its acceptance of the delivery when made, become in excess of a practical working minimum. A practical working minimum inventory is that amount of material which a producer, exercising prudent operating judgment, considers the smallest quantity of material it can hold and render war-time service at minimum standards. It may be less than the values established in Schedule C, but it shall in no case exceed them.

(3) No producer may place an order for any item of material, including material for major plant additions, if the required item or a practical substitute therefor is in the producer's inventory in excess of minimum requirements for that item.

(f) *Exceptions to paragraph (e) (2).* (1) The restrictions of paragraph (e) (2) do not apply to a producer so long as its inventory does not exceed $25,000 in value, except that such a producer must restrict its inventory to that amount of material which in the exercise of prudent operating judgment, it considers the smallest quantity it can hold and render war-time service at minimum standards. Each purchase of material by such a producer, however, must be treated as the purchase of a "short item," and is subject to the provisions of paragraph (g) below. A producer engaged in furnishing more than one of the services named in paragraph (a) (1) may consider its

inventory for each service separately for the purposes of this paragraph.

(2) The restrictions of paragraph (e) (2) do not apply to material excepted from inventory by the definition in paragraph (a) (11).

(3) [Deleted Aug. 31, 1944.]

(4) [Deleted Aug. 31, 1944.]

(5) The War Production Board may from time to time establish specific limits for permissible inventory for individual producers, modifying the provisions of Schedule C.

(6) [Deleted Aug. 31, 1944.]

(7) Notwithstanding the restrictions of paragraph (e) or of paragraph (g) below a producer may schedule an item of material for delivery in a minimum procurable commercial quantity, and in the case of cast iron, carbon steel, and non-metallic pipe, may schedule for delivery a minimum carload quantity.

(g) *Short item deliveries.* Even though it cannot schedule deliveries without exceeding the limits of paragraph (e) (2), a producer may schedule for delivery material which it will require for use in maintenance and repair, as operating supplies and for minor plant additions during the ninety-day period following the date it expects to receive such material, so long as the producer's inventory of the required material, together with material already scheduled for delivery, will be insufficient to meet requirements during such ninety-day period.

(1) [Deleted Aug. 31, 1944.]

(2) [Deleted Aug. 31, 1944.]

Part IV—Restrictions on Use of Material

(h) *Restrictions on use of material for maintenance and repair.* A job which can be classed as maintenance or repair, as those terms are defined in paragraphs (a) (4) and (5), may be done without regard to the dollar value of the material required when the following standards are met:

(1) The job must be necessary to maintain or restore service at minimum service standards or to prevent damage to facilities from serious overload, deterioration, storm, flood, climate, soil conditions, or similar contingencies.

(2) Design must emphasize economy of manpower and material as well as the substitution of the more plentiful for scarce material.

(3) No facility or part which is serviceable in its existing installation may be replaced except to avoid an imminent breakdown.

(i) *Restrictions on use of material for minor plant additions.* A job which is a plant addition, as defined in paragraph (a) (6), rather than maintenance and repair, may be done without special permission from the War Production Board, if it is a "minor plant addition"; that is, if its net material cost does not exceed $10,000. Paragraph (a) (9) explains what is meant by net material cost. However, all minor plant additions are subject to the following restrictions:

(1) No facility or part which is serviceable in its existing installation may be replaced except to avoid an imminent breakdown.

(2) Design must emphasize economy of manpower and material as well as the substitution of the more plentiful for scarce material.

(3) New facilities must be necessary for rendering service at minimum standards.

(4) No extension of a line to consumer premises may be made or connected by a producer unless it is authorized by a Supplementary U-1 order or by the approval of an application filed on Form WPB-2774. In an emergency approval may be obtained by telephone or telegraph. Confirmation must be obtained, however, by the submission of an application on Form WPB-2774.

(5) In the case of any building construction or alteration involving a cost in excess of $800 for materials and labor, the provisions of paragraph (e) of Schedule A to CMP Regulation 6, relating to structural design, and the re-

strictions on the use of certain materials contained in Appendix I, Schedule A to CMP Regulation 6 must be observed. Applications for relief from these restrictions must be filed by producers on Form WPB-2774.

(j) *Restrictions on use of material for major plant additions.* No material may be used for a major plant addition unless the job has been authorized by the approval of an application filed on Form WPB-2774. In an emergency approval may be obtained by telephone or telegraph. Confirmation must be obtained, however, by the submission of an application on Form WPB-2774.

Part V—Selling Material

(k) *Sales of material.* A producer may sell material which is in its inventory or which it acquired for major plant additions in accordance with the following rules:

(1) It may be sold without a preference rating or allotment number to any producer as defined in Order U-1, unless it is:

(i) Printing machinery and equipment, subject to Order L-226;

(ii) Construction machinery, subject to Orders L-192 and L-196;

(iii) Electric generating equipment, subject to Orders L-102 and L-94; or

(iv) Industrial power trucks, subject to Order L-112.

(2) It may be sold without a preference rating or allotment number to any person if it is used material or equipment unless it is one of the items in paragraph (k) (1) above, or:

(i) Controlled materials; or

(ii) Scrap.

(3) It may be sold pursuant to a specific written authorization from the War Production Board to the seller or to the purchaser.

(4) It may be sold without a preference rating or allotment number to a person who produces, or to the person from whom the producer purchased, the material in its present form.

(5) It may be sold without a preference rating or allotment number to a scrap dealer as scrap unless it is rubber tires or automotive parts.

(6) It may be sold without a preference rating or allotment number to the Army, Navy, Maritime Commission, or a public housing authority for the repair of an actual or threatened breakdown of their electric, gas, water or central steam heating facilities.

(7) Producers may sell material pursuant to this paragraph (k). However, if a producer chooses to do so he may sell pursuant to the provisions of Pri. Reg. 13.

(l) *Refusal to sell to other producers.* Any producer may, by specific direction from the War Production Board, be prohibited from applying or extending preference ratings assigned by this order or by any other certificate or order, upon a determination by the War Production Board, that such producer has willfully refused to sell (after receiving a bona fide offer to purchase at not less than maximum prices established by regulations of the Office of Price Administration, made by any financially responsible producer who is authorized—under applicable regulations—to accept delivery of the material specified in such offer) material in inventory when such material is required by another producer for the repair of an actual breakdown of facilities or equipment.

(1) [Deleted Aug. 31, 1944.]

(2) [Deleted Aug. 31, 1944.]

Part VI—Inventory Redistribution

(m) [Deleted Aug. 31, 1944.]

Part VII—General Provisions

(n) *Appeals.* Relief from any of the restrictions of this order may be requested by filing a letter with the War Production Board, Office of War Utilities, Washington 25, D. C., Ref.: U-1, stating the reasons why relief is necessary. If

the relief requested involves a request to make a plant addition, the request should be filed on Form WPB-2774.

(o) *Records.* In addition to the records required to be kept under Priorities Regulation 1, each producer who applies the preference ratings or allotment number hereby assigned shall maintain a continuing record of inventory and of segregated material in his possession.

(p) *Communications to War Production Board.* All reports required to be filed hereunder and all communications concerning this order, shall, unless otherwise directed, be addressed to: Office of War Utilities, War Production Board, Washington 25, D. C., Ref.: U-1.

(q) *Violations.* Any person who willfully violates any provision of this order, or who, in connection with this order, willfully conceals a material fact or furnishes false information to any department or agency of the United States, is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priorities control and may be deprived of priorities assistance.

(r) *Applicability of WPB regulations.* This order and all transactions affected hereby are subject to all applicable regulations of the War Production Board, as amended from time to time, unless there is a conflict between this order and such regulations, in which case this order shall govern, if it specifically so provides. No producer is, however, subject to the restrictions of CMP Regulation 5 nor may any producer in any way use the preference ratings therein assigned.

(s) *Special delivery quota and inventory directions.* Nothing in this order is intended to supersede any special inventory base established by a specific direction from the War Production Board to a named producer. All such directions shall remain in effect unless modified by a further specific direction to the producer affected. Special quotas for scheduled deliveries heretofore established by a specific direction from the War Production Board to a named producer are revoked.

(t) *Special provisions relating to Form WPB-2774 approvals issued prior to this amendment.* With respect to WPB-2774 authorizations issued prior to the date of this amendment and involving between $1,500 and $10,000 net material cost, producers may:

(1) Use the preference ratings and allotment numbers assigned in paragraphs (b) and (c) of this order in lieu of those specifically assigned on such a Form WPB-2774 authorization.

(2) Treat as segregated under paragraph (a) (11) any material to be used pursuant to such a WPB-2774 authorization.

Issued this 31st day of August 1944.

War Production Board,
By J. Joseph Whelan,
Recording Secretary.

Part VIII—Schedules

Schedule A

Material Classes

Material in the inventory of any producer which has an inventory, as defined in paragraph (a) (11), in excess of $25,000 shall be carried on the producer's own records and reported to the War Production Board as may be required, classified as follows:

WATER PRODUCERS

Class 1—Material for sources of supply, water treatment plants, reservoirs, elevated and pressure tanks, pumping and booster stations, including related pipe, valves, valve parts, and fittings.

Class 2—Meters.

Class 3—Transmission and distribution material (excluding meters), such as cast iron, steel and wrought iron pipe, copper and brass pipe and tubing, lead pipe, pipe

fittings, valves and valve parts, hydrants, parts for meters and hydrants, and other transmission and distribution material and supplies except pipe, valves, valve parts, and fittings included in Class 1 above.

Class 4—Other material and supplies.

GAS PRODUCERS

Class 1—Production and pumping station material.

Class 2—Meters and house regulators.

Class 3—Transmission and distribution material (excluding meters and house regulators), such as cast iron, steel and wrought iron pipe, copper and brass pipe and tubing, pipe fittings, valves and valve parts, governors and regulators, parts for meters, regulators, and governors, other transmission and distribution material and supplies.

Class 4—Other material and supplies.

ELECTRIC POWER PRODUCERS

Class 1—Generating station material.

Class 2—Switching and substation material, such as power transformers, other station equipment, parts, and material, and other material and supplies.

Class 3—Wire, cable, and bus bar, such as bare copper and aluminum, weatherproof copper underground cable, aluminum and copper shapes.

Class 4—Wood poles and cross arms.

Class 5—Meters

Class 6—Transmission and distribution material (excluding Classes 2, 3, 4 and 5 above), such as iron and steel poles, towers and parts, line hardware, distribution transformers, meter and transformer parts, and other line material and equipment (including insulators, lightning arrestors, etc.).

Class 7—Other material and supplies.

CENTRAL STEAM HEATING PRODUCERS

Class 1—Production plant material.

Class 2—Transmission and distribution material.

Class 3—Other material and supplies.

[Schedule B deleted Aug. 31, 1944.]

SCHEDULE C

LIMITS ON PRACTICAL WORKING MINIMUM INVENTORY

For purposes of paragraph (e) (2) a practical working minimum inventory (except for producers having a total inventory of $25,000 or less, who are exempted by paragraph (f)) may in no case exceed the following dollar values:

WATER PRODUCERS [2]

Class 1—The dollar value of items of material of this class in inventory on the most recent date in 1940 on which the producer's inventory was taken, increased proportionately to the increase in system output in the twelve-month period preceding the current quarter over output in 1940.

Class 2—Four-thirds of the dollar value of authorized withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies" as those terms were defined in Utilities Order U–1 as amended September 24, 1943.[1]

[1] These definitions are reprinted here for convenience in reference; please note that they differ from definitions used in the current order:

"Maintenance" means the upkeep of a producer's property and equipment in sound working condition.

"Repair" means the restoration of a producer's property and equipment to sound working condition after wear and tear, damage, destruction of parts, or the like have made such property or equipment unfit or unsafe for service.

"Operating supplies" means (1) material which is essential to the operation of any of the industries or services specified above and which is generally carried in a producer's inventory and charged to operating expense accounts, and (2) material for an addition to or an expansion of property or equipment (including a minor extension of lines), provided that such addition or expansion shall not include any work order, job, or project in which the cost of material shall exceed $1500 in the case of underground construction and $500 in the case of other construction, and provided that no single construction project shall be sub-

Class 3—Sixty per cent of the dollar value of material in this class in inventory on the most recent date in 1940 on which the producer's inventory was taken.

Class 4—Two-thirds of the dollar value of authorized withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

GAS PRODUCERS

Class 1—The dollar value of items of material of this class in inventory on the most recent date in 1940 on which the producer's inventory was taken, increased proportionately to the increase in system output in the twelve-month period preceding the current quarter over output in 1940.

Classes 2 and 3—Four-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance repair, and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

Class 4—Two-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies," as those terms were defined in Utilities Order U-1 amended September 24, 1943.[1]

ELECTRIC POWER PRODUCERS [2]

Class 1—The dollar value of items of material of this class in inventory on the most recent date in 1940 on which the producer's inventory was taken, increased proportionately to the increase in system output in the twelve-month period preceding the current quarter over output in 1940.

Class 2—The dollar value of items of material of this class in inventory on the most recent date in 1940 on which the producer's inventory was taken.

Classes 3 and 4—Four-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies" as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

Class 5—Fifty meters at each operating headquarters plus one and three-quarters per cent of the meters installed in plant on the first day of the preceding calendar quarter.

Class 6—Four-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

Class 7—Two-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

CENTRAL STEAM HEATING PRODUCERS [2]

Class 1—The dollar value of items of material of this class in inventory on the most recent date in 1940 on which the producer's inventory was taken, increased proportionately to the increase in system output in the twelve-month period preceding the current quarter over output in 1940.

Class 2—Four-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair, and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

Class 3—Two-thirds of the dollar value of withdrawals in this class made during the last nine months of 1942 for use as "maintenance, repair and operating supplies," as those terms were defined in Utilities Order U-1 as amended September 24, 1943.[1]

[Schedule D deleted Aug. 31, 1944.]

divided into parts in order to come below these limits.

[2] See Schedule A for complete identification of classes.

HOUSING UTILITIES STANDARDS AS AMENDED AUGUST 31, 1944

These Standards supersede the Housing Utilities Standards as amended May 1, 1944. They are to be used by utilities and builders of war housing in the design and construction of on-site and off-site facilities to provide electric, gas and water facilities to housing, as required by Supplementary Utilities Orders U-1-d and such other War Production Board Orders as from time to time may refer to these Standards.

They do not replace the utilities construction standards set out in Schedule I of Supplementary Utilities Order U-1-f. At present they are applicable only where there is construction or remodeling of the dwelling to be served which requires an authorization from the War Production Board to begin construction or remodeling, under Conservation Order L-41.

Standards for Water and Gas Facilities

Maximum main and service allowances. —1. The total length of water or gas mains and services to be built to serve single family detached dwelling units in the housing project shall not exceed, respectively, in lineal feet, 250 times the number of such units in the project.

2. The total length of water or gas mains and services to be built to serve any type of dwelling except a single family detached dwelling unit in the housing project shall not exceed, respectively, in lineal feet, 200 times the number of such units in the project.

These main and service allowances shall be reduced by the length of any exterior pipe furnished by the builder.

3. Notwithstanding the length-limits established in sections 1 and 2, if the housing project includes only from one to three dwelling structures, the total length of the extension may be 1,000 feet.

4. If copper or copper base alloy pipe or tubing is used by a utility it must be obtained from the utility's inventory, not to be replaced.

Standards for Electric Facilities

1. *General.*—Primary, secondary and service facilities shall be designed so as to use the smallest feasible number of transformers, **and particularly to avoid the use of transformers sizes 5 KVA and smaller wherever possible.**

2. *Maximum conductor allowances.*—The average length of conductor (including approach and site facilities) to be built to serve the housing project shall not exceed the following:

Single-family detached structures
500 feet per dwelling unit
Other types of structures (except dormitories ......400 ft. per dwelling unit
Dormitories .... 100 feet per person

These conductor allowances.—

a. Shall include service drop, secondary and primary conductors.
b. Shall include all distribution from the point of contact of the service drop to the service entrance conductor.
c. Shall exclude any service entrance conductor and interior wiring.
d. Shall be increased by one-third where electric cooking or electric cooking and water heating is specified and approved for the housing project.
e. Shall be reduced by the length of service, secondary or primary conductors which are furnished by the builder.
f. Shall be increased by 500 feet of conductor for secondary where necessary to make possible savings in the number of transformers required.
g. If the housing project includes only from one to three dwelling structures the maximum conductor allowances above may be 1,000 feet, but no additional transformer shall be installed except to replace a transformer already installed and in service.

3. *Voltage.*—Where a choice of voltage is available for primary distribution, that voltage shall be selected which will permit construction of primary facilities with the least over-all weight of conductor.

4. *Transformers.*—Where transformers are obtained from excess stocks, available sizes best adapted to the load conditions may be used. Where transformers are obtained from commercial suppliers, the maximum size of transformers shall be in accordance with the following table:

Lighting, refrigeration and small appliances		Lighting, refrigeration, small appliances, cooking and hot water	
Number of dwelling units served from transformer	Maximum transformer size	Number of dwelling units served from transformer	Maximum transformer size
1–2, inclusive	1½ KVA [1]	1	3 KVA [1]
3–4, inclusive	3 KVA [1]	2	7½ KVA
5–8, inclusive	5 KVA [1]	3	10 KVA
9–13, inclusive	7½ KVA	4–6, inclusive	15 KVA
14–19, inclusive	10 KVA	7–12, inclusive	25 KVA
20–31, inclusive	15 KVA	13–19, inclusive	37½ KVA
32–60, inclusive	25 KVA	20–31, inclusive	50 KVA
61–100, inclusive	37½ KVA	32–50, inclusive	75 KVA
		51–78, inclusive	112½ KVA
		79–109, inclusive	150 KVA

[1] See sections 1 and 2 above relative to additional conductor allowances to avoid use of this size transformer.

Where more than 100 dwelling units are served from a transformer bank, transformer capacity shall not exceed the size commercially available which is equal to or next larger than the size determined from the following table, interpolating between the figures shown in the next table.

5. *Street lighting.*—Street lighting fixtures shall not be spaced more closely than an average of one for each 350 feet of streets within the project, including streets where they bound the project.

Ornamental posts are not allowed except for withdrawal from stock without replacement. Transformers for series circuit are allowed if secured from surplus stock without replacement.

Number of dwelling units per transformer	Peak demand in KW per dwelling unit	
	Lighting, refrigeration and small appliances	Lighting, refrigeration, small appliances, cooking and hot water
100	0.375	1.4
500 and over	0.300	1.3

SUPPLEMENTARY UTILITIES ORDER U-1-d AS AMENDED AUGUST 31, 1944

PART 4500—POWER, WATER, GAS, AND CENTRAL STEAM HEAT

[Supplementary Utilities Order U-1-d, as Amended Aug. 31, 1944]

§ 4500.5 *Supplementary Utilities Order U-1-d* is amended to read as follows:

(a) *Definitions.* For the purpose of this supplementary order:

(1) "Domestic consumer" means a prospective consumer who is requesting an extension of service to a building used exclusively for dwelling purpose.

(2) "Industrial consumer" means a prospective consumer who is requesting an extension of service to a building used in whole or in part for the manufacture, processing or assembly of products or materials.

(3) "Commercial consumer" means a prospective consumer not classified in this order as "domestic" or "industrial."

(b) *Permission to build certain extensions.* In accordance with the provisions of paragraph (i) of Utilities Order U-1, extensions of electric, water, gas, and central steam heating facilities may be made or connected by producers to serve premises which are being built or remodeled under authority of a specific direction, order, certificate or other authorization for construction or remodeling issued by the War Production Board (but not to serve farm buildings except farm dwellings), when the conditions of the applicable subparagraph (1), (2), or (3) below, in addition to the conditions of subparagraph (4) below, are satisfied.

(1) *Domestic consumers.* The extension, including any part built by or for the consumer, must be built within the limits established by the Housing Utilities Standards issued by the War Production Board.

(2) *Industrial consumers.* The extension must be designed to use the smallest sizes and quantities of equipment, conductor and pipe required to furnish service at minimum standards.

(3) *Commercial consumers.* The length of the extension including any part built by or for the consumer does not exceed 1,000 feet.

(4) *All consumers.* (i) The cost of material for any continuous extension built in any calendar quarter, excluding the cost of material for any part built by or for the consumer, does not exceed $10,000.

(ii) The extension does not duplicate an adequate service of the same type already installed or constitute a standby service.

(iii) The producer has completed Form WPB-3348 for filing with the builder's application under L-41.

(c) *Other orders.* This order does not constitute a release, in the case of gas producers or consumers, from the restrictions of Utilities Order U-7 or Limitation Order L-174.

Issued this 31st day of August 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

SUPPLEMENTARY UTILITIES ORDER U-1-e REVOCATION AS OF AUGUST 31, 1944

PART 4500—POWER, WATER, GAS, AND CENTRAL STEAM HEAT

[Supplementary Utilities Order U-1-e, Revocation]

Section 4500.6 *Supplementary Utilities Order U-1-e* is hereby revoked. Extensions of service to victory gardens may be made under the provisions of Supplementary Utilities Order U-1-f as amended. This revocation does not affect any liabilities incurred under this order.

Issued this 31st day of August 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

SUPPLEMENTARY UTILITIES ORDER U-1-f AS AMENDED AUGUST 31, 1944

PART 4500—POWER, WATER, GAS, AND CENTRAL STEAM HEAT

[Supplementary Utilities Order U-1-f, as Amended Aug. 31, 1944]

§ 4500.7 *Supplementary Utilities Order U-1-f*—(a) *Definitions.* For the purposes of this supplementary order:

(1) "Domestic consumer" means a prospective consumer who is requesting an extension of service to a building used exclusively for dwelling purposes.

(2) "Industrial consumer" means a prospective consumer who is requesting an extension of service to a buliding used in whole or in part for the manufacture, processing or assembly of products or materials.

(3) "Commercial consumer" means a prospective consumer not classified in this order as "domestic" or "industrial."

(b) *Permission to build certain extensions.* In accordance with the provisions of paragraph (i) of Utilities Order U-1, extensions of electric, water, gas, and central steam heating facilities may be made or connected by producers when all of the following conditions are satisfied:

(1) If construction or remodeling by the consumer is involved, no specific direction, order, certificate or other authorization for construction has been issued by the War Production Board to authorize such construction or remodeling. If such authorization has been issued, the construction of utility facilities, except to farm buildings other than farm dwellings, is governed by Supplementary Utilities Order U-1-d.

(2) Extensions, including any part built by or for the consumer, can be built within the limits of the Utilities Construction Standards, shown in Schedule I of this order. In the case of extensions of natural gas facilities to serve lessors of property on which producing natural gas wells have been completed, the portion built by or for the consumer need not be included.

(3) The cost of material for any continuous extension built in any calendar quarter, excluding the cost of material for any part built by or for the consumer, does not exceed $10,000.

(4) The extension does not duplicate an adequate service of the same type already installed or constitute a stand-by service.

NOTE: Former subparagraph (4) deleted; former subparagraph (5) redesignated (4) Aug. 31, 1944.

(c) *Other orders.* This order does not constitute a release, in the case of gas producers or consumers, from the restrictions of Utilities Order U-7 or Limitation Order L-174.

(d) *Effect of amendment of this order on construction started.* Construction of extensions permitted by Supplementary Utilities Order U-1-f prior to this amendment may be completed if construction other than right of way clearing has started prior to the date of this amendment.

Issued this 31st day of August 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

SCHEDULE I—UTILITIES CONSTRUCTION STANDARDS

The material used in extensions permitted by Supplementary Utilities Order U-1-f must conform to the limitations set out in this Schedule I and must not exceed, in dollar value, the limits of paragraph (b) (3).

A. PERMITTED TYPES OF CONDUCTOR AND PIPE

I. *Domestic extensions.* a. *Electric conductor for primary, secondary, and service drop:*

(1) Any type or size of conductor having conductivity equal to or less than that of No. 6 AWG copper, or

(2) Any type or size of conductor which can be obtained from the excess inventory of any producer.

b. *Pipe.* Any type of pipe.

II. *Commercial and industrial extensions.* No limitation, except as shown below in B, II.

B. PERMITTED QUANTITIES OF CONDUCTOR TRANSFORMERS AND PIPE

I. *Domestic extensions.* a. *For electric service.* (1) In cases where the consumer has in his possession an electric range, refrigerator, or washing machine, one transformer and not more than 1,000 feet of extension per consumer including primary, secondary, and service drop; (2) in other cases than described in (1) above, not more than 1,000 feet of extension per customer including primary, secondary and service drop, but no transformer except to replace transformers in service.

b. *For water, gas or central steam heating service,* not more than 1,000 linear feet of main and service pipe for each consumer. However, if copper or copper base alloy pipe or tubing is installed by a producer, such pipe or tubing must be obtained from the inventory of a producer and may not be replaced.

c. [Deleted Aug. 31, 1944.]

II. *Commercial and industrial extensions.* a. In the case of facilities to serve an industrial or commercial consumer who is (1) engaged, as his principal activity, in the manufacture of a product or in the conduct of a business or activity listed in Schedules I or II of CMP Regulation 5, as amended; or (2) an electric, water, gas, steam heat, telephone or telegraph utility; or (3) engaged in the petroleum industry, except in retail marketing, as those terms are defined in Preference Rating Order P–98–b; or (4) engaged in the business of mining, or of burning refractories, and has been assigned a serial number under Preference Rating Order P–56; or (5) engaged in the business of radio communication or radio broadcasting; or (6) a hospital, the smallest sizes and quantities of equipment, conductor and pipe required to furnish service at minimum standards.

b. In the case of facilities to serve an industrial or commercial consumer who is not engaged in a business or activity listed above, not more than 1,000 feet of extension per consumer. For electric extensions this length shall include primary, secondary and service drop and no new transformer installations may be made except to replace transformers installed and in service.

C. PERMITTED QUANTITIES OF NON-METALLIC PIPE

NOTE: Deleted April 6, 1944.

SUPPLEMENTARY UTILITIES ORDER U–1–g AS AMENDED AUGUST 31, 1944

PART 4500—POWER, WATER, GAS, AND CENTRAL STEAM HEAT

[Supplementary Utilities Order U–1–g, as Amended Jan. 22, 1944]

TEMPORARY BUSINESS, CIVIC OR RECREATIONAL ACTIVITIES

§ 4500.8 *Supplementary Utilities Order U–1–g.* In accordance with the provisions of paragraph (i) of Utilities Order U–1, temporary extensions of electric, water, gas, and central steam heating facilities may be made or connected by producers to serve temporary business, civic or recreational facilities when all of the following conditions are satisfied:

(a) The cost of material for such utility extensions is less than $1,500.

(b) Such extensions will be dismantled at the expiration of ninety days from date of installation and all material salvaged and returned to inventory.

(c) The extension does not duplicate an adequate service of the same type already installed, or constitute a standby service.

Issued this 31st day of August 1944.

WAR PRODUCTION BOARD,
By J. JOSEPH WHELAN,
Recording Secretary.

Willing Water Says:

We Are Flushing Hydrants!

The annual spring hydrant flushing is now in progress. For a short time you may draw some "rusty" water from your faucets. Such water is not "pretty", but don't be afraid of it—it contains nothing harmful.

We regret that this flushing is necessary twice a year to clear the mains of the rust that accumulates. If we did not do this you would be inconvenienced by rusty water frequently. We know! We tried it once!

After the job is finished, City water will be restored to its usual sparkle and clearness. There will be no flushing on Mondays—the usual family wash day.

We ask your co-operation.

CITY LIGHT AND WATER UTILITIES

City Hall—Phone 7111

Water Conservation, published by the A.W.W.A. and now available at the reduc price of $1.00, will help *you* plan a water conservation program.